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Research Article

Enhancing Fatty Acid Composition and Seed Yield in Brassica rapa through Breeding Techniques

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Abstract

The goal of the current study was to identify the most effective selection criteria for increasing rapeseed production (Brassica rapa L.). In order to assess the means and path analysis for yield and quality components, thirty F1 crosses, thirteen parents, and one check cultivar of Brassica rapa were sown at the University of Agriculture, Faisalabad, in the years 2021–2022. The path coefficient showed that the number of seeds/plants, 100 seed weight, days to 50% flowering, days to 50% maturity, and seeds/silique all directly and positively correlated with the amount of seeds produced per plant. For every character, the genotypes were found to be considerably varied. The number of primary branches per plant, the number of siliquae per plant, and the length of the siliqua were shown to be the traits that contributed most to the seed yield per plant in the path co-efficient analysis. These qualities could be selected for in a future hybridization programme.

Keywords: Rapeseed, variability, path co-efficient, Plant breeding

1. Introduction

For international agriculture and related sectors, oil crops are extremely important. The family Brassicaceae, which includes rapeseed (Brassica rapa L.), is one of the world's most significant producers of vegetable oil [1]. It is a valuable oil seed that has gained a lot of attention in recent years. Brassica seed oils are produced and used in a way that places them 3rd among oilseed crops in terms of producing vegetable oils, after soybean and oil palm, and 5th in terms of producing oilseed proteins [2]. The composition of an oil's fatty acids determines how it is used. Approximately 60% of conventional oilseed rape (OSR) and 10% of C18:3 are present. Because of its high concentration of polyunsaturated fatty acids and low concentration of saturated fatty acids, it has great nutritional quality; nevertheless, for the same reasons, it becomes unstable at high temperatures. On the other hand, variations of OSR known as high-oleic low-linolenic (HOLL) exhibit superior oxidative stability at elevated temperatures because to their high concentration of oleic acid (C18:1 > 75%) and low content of linolenic acid (C18:3 < 3.5%).

The yield is a complicated characteristic that depends on numerous other morphological features, the majority of which are inherited quantitatively [2]. Examining each trait's contribution is crucial in order to focus more on the traits that have the greatest impact on seed yield [3]. The relationship between the characters could not be adequately explained by a simple correlation study. As a result, Korkut et al. recommend using path coefficient analysis to fully and thoroughly determine the impact of the independent variable on the dependent one [4]. The development of shorter-duration, higher-yielding, improved oil seed varieties with superior quality are the most crucial and urgent concerns. Since the ultimate objective of any crop improvement programme is to generate high yielding varieties, a significant degree of genetic variability and heritability must exist. For this reason, correlation can be used to identify the constituent traits of a complicated trait such as yield. More detailed information on the direct and indirect effects of each component character on seed yield is provided by the path co-efficient study. It has been widely employed in breeding efforts in various crop species by various researchers and aids breeders in explaining direct and indirect effects. The goal of the current studies was to determine selection criteria and association for yield components in rapeseed (Brassica rapa).

2. Material and Method

The experiment was carried out in 2021–2022 in the Department of Plant Breeding and Genetics' research area at the University of Agriculture in Faisalabad, Pakistan. For this investigation, thirteen parent varieties from the Brassica rapa yield trial—ten lines, three testers, and Chakwal Sarson and Thirty F1 crosses—with varying genetic backgrounds were chosen. Under Randomised Complete Block Design (RCBD), three replicates of a Line× tester mating design were used to plant these genotypes. Every plot had three rows for every input and was five metres in length. With the aid of a seed drill, seeds were sown, with 45 cm separating each row. Throughout the growth season, standard agronomic and cultural procedures were followed in the experiment. Data on days to 50% flowering, days to 50% maturity, plant height (cm), number of primary branches per plant, number of siliquae per plant, number of seeds per silique, 100 seed weight (g), yield per plant (g), percentage of erucic acid, percentage of oleic acid, percentage of linoleum acid, and percentage of protein were recorded on randomly chosen plants that were tagged. Every measured trait was subjected to the Analysis of Variance procedure as suggested by Steel and Torrie [5].

3. Results and Discussion

The correlation coefficient is divided into direct and indirect effects using path coefficient analysis. It indicates whether the qualities' relationship to yield results from their direct influence or from their indirect effect through other traits. The greatest positive direct effect of seeds per plant on yield (0.549) was found by the data (Table 1 and 2).

Table 1: Direct (bold) and indirect effects of various yield and fatty acids related traits of Brassica rapa L. in F1 cross combinations

	DFI	DFC	DSF	PH	ASPP	NPBPP	NSBPP	NSPP	SS	HSW	YPP	OC	PC	Glu.C	EAC
DFI	0.35	-0.15	0.28	-0.01	0.01	-0.01	0.006	0.14	0.09	0.003	0.274	0.261	0.046	-0.006	-0.006
DFC	-0.23	0.22	0.02	-0.11	0.04	0.01	-0.003	0.15	-0.02	-0.016	0.038	0.245	0.002	0.074	0.074
DSF	0.27	0.18	0.04	0.12	0.01	0.02	0.001	0.11	0.004	0.002	0.038	0.201	0.045	-0.015	-0.015
ASPP	0.01	0.01	0.09	-0.25	0.03	0.07	-0.005	0.02	-0.0003	0.006	0.070	0.185	0.010	0.128	0.128
PH	0.01	0.04	0.01	-0.03	0.25	0.004	-0.00003	0.09	-0.07	0.02	0.208	0.210	0.019	0.068	0.068
NPBPP	-0.03	0.03	-0.15	-0.15	0.01	0.12	-0.02	0.03	0.01	0.004	0.086	0.147	0.023	0.086	0.086
NSBPP	0.14	-0.05	0.03	0.08	-0.00043	-0.09	0.02	-0.05	0.007	-0.01	0.022	0.012	0.030	0.062	0.062
SPP	0.13	0.09	0.02	-0.02	0.06	0.01	-0.002	0.38	0.10	-0.02	0.502	0.063	0.030	0.004	0.004
SS	0.14	-0.02	0.13	0.03	-0.08	0.006	0.0005	0.15	0.23	0.0001	0.230	0.078	0.033	-0.015	-0.015
HSW	-0.02	0.04	0.02	0.02	-0.05	-0.005	0.0001	0.11	-0.00034	-0.08	0.412	0.037	0.058	0.002	0.262
YPP	0.502	0.029	-0.066	0.172	0.262	0.007	0.022	0.664	0.502	0.074	0.549	-0.002	-0.038	0.033	0.560
OC	0.230	0.018	-0.089	0.069	0.560	-0.033	-0.072	0.665	0.230	-0.015	0.016	0.030	0.106	0.023	-0.046
PC	0.412	0.005	0.026	0.227	-0.046	0.023	-0.037	0.607	0.412	0.128	0.857	-0.022	-0.005	0.013	0.011
Glu.C	0.549	-0.020	-0.005	0.011	0.011	0.014	-0.016	-0.064	0.549	0.068		0.046	0.108	0.037	0.174
EAC	0.016	0.058	0.000	0.089	0.174	0.005	0.030	1.024	0.016	0.086		0.040	0.105	0.006	0.240

DFI = Days to flower initiation, DFC = Days to flower completion, DSF = Days to silique formation, ASPP= Aborted silique per plant, PH= Plant height, NPBPP= Number of primary branches per plant, NSBPP= Number of secondary branches per plant, NSPP= Number of silique per plant, SS = Seed per silique, HSW = hundred seed weight, YPP = Yield per plant, OC= Oil content, PC= Protein content, Glu= Glucosinolate content and EAC= Erucic acid content

3.1. Path Coefficient Analysis

Table 1 shows both the direct and indirect effects on hundred seed weight of various yield and fatty acid related variables. The number of siliques per plant had a positive direct effect on yield per plant, followed by plant height and days to 50% silique development, according to path analysis used to indicate direct and indirect effects. There was a maximum favourable direct influence on 100 seed weight, days to 50% flower initiation. Number of seeds per silique showed the maximum positive indirect effect of days to 50% silique formation, days to 50% flower completion, number of aborted silique per plant, plant height, glucosinolate contents, and erucic acid contents. The hundred seed weight had the greatest positive indirect influence through the days leading up to 50% silique development. Days to flowering and silique length were found to have a positive direct effect on yield per plant, however plant height was found to have a negative direct effect [6, 7].

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Table 2: Direct (bold) and indirect effects of various yield and fatty acids related traits of Brassica rapa L. in F2 cross combinations

	DFI	DFC	DSF	PH	ASPP	NPBPP	NSBPP	NSPP	SS	HSW	YPP	OC	PC	Glu.C	EAC
DFI	0.22	0.02	-0.11	0.04	0.01	-0.003	0.15	-0.02	-0.016	0.038	0.245	0.002	0.074	0.074	0.02
DFC	2.363	-0.386	1.418	-0.424	-0.117	-0.323	4.172	0.426	-0.355	-0.516	0.333	0.383	0.250	0.069	-5.363
DSF	-0.575	-1.604	1.629	1.087	0.139	-0.266	2.615	-0.104	-1.222	-0.013	-1.751	0.157	0.377	0.235	-0.575
ASPP	-1.797	-1.388	3.232	-1.174	0.128	-0.071	-1.079	0.177	-0.126	0.279	-1.223	0.227	1.166	0.053	-1.797
PH	-0.334	1.053	0.730	-2.800	-0.279	-0.298	0.548	0.260	1.317	-0.078	4.009	0.265	1.074	-0.203	-0.334
NPBPP	1.087	-0.870	0.938	3.282	0.579	-0.109	0.651	0.265	-0.612	-0.452	-3.544	-0.337	-0.711	0.178	1.087
NSBPP	-1.120	-0.620	0.195	-1.311	0.041	-1.547	3.758	0.853	-0.656	-0.198	1.587	-0.543	-0.377	0.157	-1.120
SPP	-2.592	-1.092	-0.529	0.432	0.043	-0.673	8.632	0.352	-0.983	-0.762	-1.651	-0.166	-1.198	0.198	-2.592
SS	-1.242	0.204	0.407	-0.961	0.083	-0.717	1.654	1.840	-0.961	-0.097	0.998	-0.660	-0.514	0.006	-1.242
HSW	-0.683	-1.578	0.192	3.209	0.127	-0.363	3.041	0.634	1.790	-0.238	-0.865	-0.384	-0.715	0.187	-0.683
YPP	2.593	0.047	1.108	0.499	-0.245	0.287	-6.162	-0.168	0.624	1.067	-0.455	-0.088	-0.743	-0.200	2.593
OC	0.286	-1.009	0.828	4.363	0.328	0.393	2.280	-0.294	-0.386	0.077	-6.249	-0.144	-0.811	0.152	0.286
PC	1.506	0.415	-0.705	1.321	0.143	-0.615	1.050	0.889	-0.785	0.068	-0.662	0.366	-1.172	0.075	1.506
Glu.C	0.533	0.541	-1.961	2.902	0.163	-0.231	4.111	0.376	-0.793	-0.315	-2.015	-0.633	-0.516	0.136	0.533
EAC	-1.076	-2.457	0.652	4.008	0.299	-0.708	4.956	0.035	-1.514	-0.619	-2.765	-0.299	-0.991	0.345	-1.076

DFI = Days to flower initiation, DFC = Days to flower completion, DSF = Days to silique formation, ASPP= Aborted silique per plant, PH= Plant height, NPBPP= Number of primary branches per plant, NSBPP= Number of secondary branches per plant, NSPP= Number of silique per plant, SS = Seed per silique, HSW = hundred seed weight, YPP = Yield per plant, OC= Oil content, PC= Protein content, Glu= Glucosinolate content and EAC= Erucic acid content

3.2. Direct and indirect effects of yield and fatty acid related traits of rapeseed on yield in F_2

Table 2 shows both the direct and indirect effects on hundred seed weight of various yield and fatty acid related variables. Days to 50% flower initiation, Days to 50% silique development, number of secondary branches per plant, and number of seeds per silique were determined during the evaluation of developed breeding material. The most useful effect on hundred seed weight was observed in days to 50% flower completion. The number of seeds per silique revealed the maximum useful indirect influence of the following variables: days to 50% silique formation, days to 50% flower completeness, number of aborted siliques per plant, plant height, glucosinolate levels, and erucic acid. High oil concentrations showed the maximum positive indirect effect of erucic acid amounts. Days to flowering, days to maturity, and 100 seed weight were found to have a positive direct effect on yield by [8, 9].

4. Conclusion

Among the thirty advanced F1 crosses and one check variety that were examined, a broad range of variances were found in the majority of the characteristics. Based on the Path Coefficient Analysis, it was determined that the following factors had a positive direct impact on plant yield: days to 50% flowering, days to 50% maturity, number of primary branches per plant, number of silique per plant, length of silique, and number of seeds per silique; on the other hand, days to 50% flowering, plant height, number of secondary branches per plant, and hundred seed weight had a negative direct impact. The path co-efficient analysis led to the conclusion that the three factors that contributed most significantly to the seed yield per plant—number of primary branches per plant, number of silique per plant, and silique length—could be taken into account for upcoming hybridization programmes.Selection would ultimately be advantageous for the improvement of the crop and effective for these features.

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