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Assessment of Genetic Variability, Correlation and Path Coefficient Analysis in Backcross Derived Oat Breeding Lines

Khushbu[1], V.K. Sood[2] and Sanjay Kumar Sanadya[3]

[1]Ph.D. Scholar, Genetics and Plant Breeding, College of Agriculture, CSKHPKV, Palampur (Himachal Pradesh), India.
[2]Head of Department, Genetics and Plant Breeding, College of Agriculture, CSKHPKV, Palampur (Himachal Pradesh), India.
[3]Assistant Professor, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab 140406 (Himachal Pradesh), India.

(Corresponding author: Khushbu)*
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ABSTRACT: Genetic variation is a prerequisite for selection of desirable plants in any crop improvement. An experiment was carried out to study the genetic variability parameters and correlation and path analysis in 39 backcrossed-derived oat lines along with parents during winter season 2022-23 in augmented design. Analysis of variance showed significant men square due to genotypes indicating sufficient genetic variation for seed yield and component traits. The genetic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) ranged from 2.61% for days to 75% maturity to 12.61% for harvest index. The studied traits had low to high genotypic and phenotypic coefficient of variation in backcross derived oat breeding lines. Genotypes exhibited high heritability coupled with genetic advance as percent of the mean for seed yield per plant, harvest index, 100-seed weight, leaves per plant and tillers per plant. Seed yield *per se* performance revealed three lines G10 (HJ-8-80-39-47-44), G16 (HJ-8-80-28-55-64) and G17 (HJ-8-80-36-78-67) that exhibited superiority over recurrent parent HJ-8. Seed yield per plant showed a positive association with days to 50 % flowering, plant height, tillers per plant, leaves per plant, harvest index and 100-seed weight. Surprising, 100-seed weight showed positive significant associations with all the tested characters. Harvest index showed the direct effect with seed yield per plant. There was adequate genetic variability in the tested breeding genotypes to support oat breeding for improved seed yield through direct selection for harvest index and indirect selection for tillers, leaves and 100-seed weight. MABB is the speedy breeding of plants for the disease resistance in 2-3 generations rather than the traditional backcross breeding requires 7 to 8 generations.

Keywords: Variability, Correlation, Path analysis, Selection, Direct effects.

INTRODUCTION

Oats is the annual cool-season crop is mostly grown in humid regions of temperate climates worldwide used both as forage and grain are good source of protein, fibres and minerals. It has excellent growth habit, quick recovery after cutting and provides good quality herbage (Kumari and Kaushal 2022). Oat is considered as highly nutritious cereal for human consumption as it is a excellent source of f protein, carbohydrates, lipid, minerals, vitamins and phenolic compounds (Sood *et al*., 2022). Oats are becoming more and more popular due to their nutritional makeup and the multifunctional benefits of several select bioactive compounds. Of these, beta-glucan, which is present in oat grains as dietary fiber, is the main active compound that is known to possess antidiabetic and cholesterol-lowering properties (Sait *et al.*, 2020). Oats also contain significant amounts of other bioactive compounds, including phenolic acids, tocols, sterols, avenacosides and avenanthramides. Consuming oats has also been shown to improve gut microbiota and promote immunomodulation. It is originated from the natural aggregation of the three ancestral diploid genomes, AA, CC, and DD and it is an autogamous, allohexaploid (2n = 6x = 42) (Rines *et al*., 2006). Furthermore, genetic correlation is essential in order to identify the most desired yield-contributing traits that may be utilized as indirect selection tools for yield and to boost selection efficiency by generating indirect gains when selection is carried out on low heritability traits (Machado *et al*., 2017). Measures of the mutual relationship between plant traits and the characters on which selection can be made for the genetic improvement of yield involve the correlation coefficient, which estimates the degree and direction of the association between a pair of characters and aids in the simultaneous improvement of the correlated characters through selection. In order to improve yield, it is necessary to investigate the presence of components and the nature of their association (Negi *et al*., 2019). The complex character seed yield depends on various yield contributing traits. Variations in the environment have a significant impact on this attribute, which is governed by polygenes. Therefore, the observed variability must be divided into components that are heritable and nonheritable, as shown by the genotypic and phenotypic coefficients of variation (GCV and PCV) (Kebede *et al*. 2023). The foundation of a good breeding program is the study of both direct and indirect effects and their components; as a result, improving yield can be approached more successfully by focusing on the performance of component traits and the selection of closely related traits. Due to variations in genetic makeup and growth conditions, oat genotypes exhibit varying nutritional value, fodder production, and grain yield performances. Therefore, it is crucial to take use of existing variations in oat genotypes for appropriate selection and further advancement.

MATERIAL AND METHODS

The experiment was conducted in the Fodder Farm of the Fodder Section, COA, CSK HPKV, Palampur and the lab work was done at Molecular Cytogenetics & Tissue Culture Laboratory of the Department of Genetics & Plant Breeding, CSK HPKV, Palampur. The experiment design of this work was Augmented design with 39 BC_3F_2 lines two parents viz., HJ-8 and JPO-46 as a check. During year 2022-2023 the BC_3F_2 lines of the cross HJ-8 x JPO-46, the resultant of the consecutive backcrossing for three generations were evaluated for agro morphological traits. The material used in the present investigation comprised of two oat varieties HJ-8 and JPO-46, one is a cultivar created for widespread cultivation by crossing OS-7 x S-3021 P15, HJ-8 was released by Chaudhary Charan Singh Haryana Agricultural University, Haryana. The variety's output of green fodder yield of variety is 65 t/ha. It is fast growing and has a better regeneration which is appropriate for two cuts and is high yielding potential cultivar but highly susceptible to powdery mildew. JPO-46 is from Jawahar Lal Nehru Krishi Vishavidalya and is highly resistant to powdery mildew variety JPO-46.

RESULTS AND DISCUSSION

A. Analysis of variance

The analysis of variance (ANOVA) yielded significant results, indicating that the mean sum of squares attributed to breeding lines exhibited significance for all the studied traits, with the exception of 100-seed weight. This outcome suggests that there is ample variability among the breeding lines, as summarized in Table 1. The presence of genetic diversity plays a pivotal role in the selection of desirable oat plants for breeding programs, particularly in the context of economically important traits influenced by multiple minor genes. Thus, genetic variation assumes a critical role in facilitating the success of crop improvement program (Sanadya *et al.*, 2022). Furthermore, (Kumar *et al*., 2022a) conducted an evaluation of both wild and cultivated oat species to assess genetic variation concerning seed yield and its various components, and their findings indicated a substantial level of genetic variation for studied seed yield and component traits.

Table 1: Analysis of variance for yield traits among tested oat breeding materials.

Sources	Df	D50F	D75M	PH	TPP	LPP	BYPP	SYPP	HI	TW
Blocks	2	6.16	7.24	14.48	7.24	7.24	7.24	7.24	7.24	7.24
Genotypes	40	21.52*	20.41*	9.27*	1.82*	22.61*	12.51*	11.56*	15.31*	0.11
Checks	1	42.67*	6.64*	8.12*	17.62*	416.16*	21.06*	76.39*	60.81*	0.38
Lines	38	18.79	21.03	9.36	1.22	9.53	10.93	9.91	12.81	0.98
Test vs Check	1	103.51	10.66	7.15	9.86	126.42	63.64	9.97	65.34	0.75
Error	2	0.16	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01

*, significant at 5% levels of significance ($p<0.05$), SYPP= seed yield per plant, PH= plant height, LPP= leaves per plant, TPP=tillers per plant, D50F= days to 50% flowering, TW= 100-seed weight, BYPP= biological per plant, D75M= days to 75% maturity, HI= harvest index.

B. Performance per se of parents and back cross-derived lines

For different agro-morphological characters data on mean performance and parental genotypes are presented in the Table 2. The oat breeding lines exhibited significant variation for this trait with days to 50% flowering ranging from 125-147 days. One entry G28 was significantly low days to 50% flowering over the respective check. The adjusted mean values for plant height ranged from 99.82-112.03cm. Eleven oat lines were found significantly low plant height over the respective check. The number of leaves per plant mean values varied from 24.17- 45.03 and eight lines were significant higher number of leaves per plant as compared to check. Fourteen lines were found to be significantly superior as compared with respective check for tillers per plant and for days to 75% maturity, sixteen oat lines exhibited significantly lower mean values as compared to respective check. The oat lines exhibited significant variation with days to 75% maturity ranging from 163-186 days, whereas tillers per plant varied from 9.47- 15.45. A significant variation was recorded for biological yield per plant in oat lines with biological yield ranging from 85.43-106.65 g and twenty four lines exhibited superiority over respective check. Similarly, significant variation was recorded for seed yield per plant in oat lines with mean value ranging from 20.75-37.59 g. Among studied lines, three lines namely G10, G16 and G17 exhibited superiority over recurrent parent HJ-8. In addition, two lines (G16 and G17) showed superiority for harvest index and mean value ranged from 18.56 - 37.92%. The hundred seed weight of breeding lines ranged from 1.03 to 5.91 g whereas thirteen lines exhibited superiority over respective check.

Table 2: Mean performance for yield traits in HJ-8 derived breeding lines.

Genotypes	Code	D50F	PH	LPP	TPP	D75M	BYPP	SYPP	HI	TW
HJ-8-1-6-15-11	G1	135.2	106.1	36.8	11.9	171.0	90.6	24.5	27.1	3.7
HJ-8-1-15-17-19	G2	134.2	109.8	36.5	12.1	179.0	96.8	25.9	26.7	3.3
HJ-8-1-15-17-22	G3	130.2	104.6	35.1	11.3	174.0	96.2	32.3	30.4	3.6
HJ-8-1-17-21-26	G4	136.2	105.5	43.0	13.7	170.0	91.1	27.9	27.6	3.9
HJ-8-1-17-21-29	G5	140.2	103.2	36.3	12.8	178.0	91.7	20.8	18.6	3.7
HJ-8-78-17-29-30	G6	142.2	110.3	31.6	11.5	177.0	97.0	27.6	26.0	3.9
HJ-8-80-36-33-35	G7	137.2	105.3	36.1	10.1	170.0	92.2	25.8	28.0	3.9
HJ-8-80-36-33-39	G8	139.2	109.8	39.3	14.9	173.0	93.8	28.4	27.3	4.2
HJ-8-80-39-47-41	G9	141.2	111.8	39.5	10.1	172.0	92.6	25.5	25.0	3.4
HJ-8-80-39-47-44	G10	145.2	110.0	37.2	14.9	176.0	93.4	37.6	36.4	3.1
HJ-8-81-45-58-49	G11	138.2	102.3	39.7	13.5	179.0	91.8	26.2	28.5	3.8
HJ-8-81-45-58-53	G12	136.2	100.0	31.0	12.7	180.0	99.7	25.7	25.9	3.6
HJ-8-81-50-61-57	G13	141.2	102.5	36.6	13.7	179.0	92.1	31.2	30.9	3.2
HJ-8-80-28-55-60	G14	134.7	109.7	41.3	13.9	178.9	99.4	30.2	30.9	5.4
HJ-8-80-28-55-61	G15	141.7	112.0	37.6	14.2	177.9	94.8	33.3	35.7	5.8
HJ-8-80-28-55-64	G16	136.7	108.3	42.9	14.9	176.9	94.3	35.2	37.9	5.1
HJ-8-80-36-78-67	G17	143.7	109.9	45.0	15.3	180.9	93.5	33.9	36.9	5.4
HJ-8-80-36-96-69	G18	146.7	107.2	42.4	14.1	177.9	94.9	32.9	35.2	5.1
HJ-8-81-46-103-70	G19	142.7	106.7	43.1	15.5	174.9	93.7	30.1	32.6	5.1
HJ-8-81-50-117-71	G20	142.7	107.2	39.1	13.5	181.9	101.3	28.9	29.1	5.1
HJ-8-87-53-121-75	G21	132.7	111.6	43.7	14.3	181.9	102.7	25.6	25.5	5.9
HJ-8-90-57-134-79	G22	136.7	108.0	41.8	14.1	182.9	94.6	32.1	34.4	5.2
HJ-8-90-59-137-83	G23	140.7	103.9	42.4	15.2	176.9	94.2	31.0	33.4	5.1
HJ-8-90-59-137-86	G24	141.7	109.9	41.2	12.6	181.9	97.5	31.1	29.6	5.2
HJ-8-90-67-142-87	G25	140.7	102.2	41.1	13.6	185.9	94.6	26.1	28.0	4.9
HJ-8-87-70-155-89	G26	146.7	110.1	37.3	13.0	172.9	94.0	25.6	27.6	5.2
HJ-8-87-70-155-90	G27	135.2	103.2	35.2	11.0	171.1	90.0	27.2	29.8	1.0
HJ-8-87-70-164-92	G28	125.2	104.7	38.0	10.1	163.1	97.7	28.8	28.6	1.4
HJ-8-87-70-164-93	G29	128.2	106.7	34.8	10.7	169.1	95.2	26.5	27.5	1.4
HJ-8-87-77-169-95	G30	138.2	101.1	31.0	12.1	176.1	87.5	27.9	31.5	1.4
HJ-8-87-77-169-97	G31	135.2	102.8	31.7	10.3	172.1	96.6	27.0	27.5	1.6
HJ-8-90-67-171-99	G32	133.2	107.7	33.5	10.1	169.1	95.7	25.6	26.4	1.8
HJ-8-91-70-179-101	G33	136.2	103.2	37.7	11.6	178.1	87.0	24.7	26.4	1.5
HJ-8-91-79-185-102	G34	134.2	108.6	32.8	10.8	169.1	89.3	29.8	32.8	1.4
HJ-8-91-79-185-102	G35	129.2	99.8	31.4	11.6	182.1	96.7	25.6	26.0	1.3
HJ-8-93-84-190-105	G36	135.2	103.6	34.9	10.8	179.1	92.3	24.4	26.1	1.4
HJ-8-96-91-192-107	G37	130.2	105.0	29.6	10.9	168.1	85.4	23.0	26.7	1.7
HJ-8-96-99-197-109	G38	131.2	108.0	35.1	11.3	169.1	90.9	26.2	28.4	1.5
HJ-8-96-99-197-112	G39	133.2	102.4	36.9	11.5	182.1	89.2	27.7	24.8	1.7
JPO-46	G40	130.0	103.9	24.2	9.5	178.3	88.5	26.0	29.5	3.6
HJ-8	G41	135.3	106.3	40.8	12.9	176.2	92.3	33.2	35.9	3.1
Grand mean		**136.9**	**106.2**	**37.2**	**12.5**	**175.9**	**93.7**	**28.3**	**29.3**	**3.5**
Critical difference (0.05)										
Two treatments (different block)		3.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Treatment and check		2.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

*, significant at 5% levels of significance ($p<0.05$), SYPP= seed yield per plant, PH= plant height, LPP= leaves per plant, TPP=tillers per plant, D50F= days to 50% flowering, TW= 100-seed weight, BYPP= biological per plant, D75M= days to 75% maturity, HI= harvest index.

C. Genetic variability parameters

Wide range of phenotypic and genotypic variances was observed in studied breeding materials for all the tested characters (Table 3). Phenotypic coefficient of variation (PCV) was more than genotypic coefficient of variation (GCV) for the most of traits except biological yield per plant, days to 75% maturity and harvest index. GCV was observed for traits ranging from 12.19 (harvest index) to 2.61 (days to 75% maturity). The highest GCV and PCV were recorded for harvest index followed by seed yield per plant, 100-seed weight, tillers per plant and leaves per plant. The lowest GCV and PCV were also observed by previous researchers Kumar *et al.* (2022b) in wild and cultivated oat species. High heritability in the broad sense associated with high genetic advance revealed a strong contribution of additive genetic variance for the expression of traits and the selection based on these traits could play a vital role in improving grain yield. High heritability coupled with high genetic advance as a per cent of mean was recorded for seed yield per plant, harvest index, 100-seed weight, leaves per plant and tillers per plant indicated the least influenced by environment and governed by additive gene action. In contrast, days to 50% flowering and days to 75% maturity showed high heritability with moderate genetic advance as per cent of the mean. Plant height and biological yield per plant showed high heritability with low genetic advance as per cent of mean, indicating that these characters showed non-additive gene action. Knowledge of the high value of heritability and predicted genetic advance clarifies that the selection among genotypes would be effective for yield and components traits (Kumar *et al.*, 2022a).

Table 3: Genetic parameters of variability in oat derived lines for yield traits.

Traits	Range	PCV	GCV	Heritability (%)	GA % of mean
D50F	134.07-139.75	3.16	3.15	99.11	8.86
D75M	175.28-176.54	2.61	2.61	99.94	9.45
LPP	36.55-37.80	8.30	8.29	99.88	17.11
TPP	11.86-13.12	8.87	8.83	99.11	18.15
PH	105.58-106.84	2.88	2.87	99.88	6.3
TW	2.82-4.08	9.08	8.58	89.21	16.72
SYPP	28.50-29.49	11.14	11.13	99.89	22.95
BYPP	93.07-94.33	3.53	3.53	99.89	7.27
HI	28.70-29.96	12.19	12.19	99.92	25.14

GA= genetic advance, SYPP= seed yield per plant, PH= plant height, LPP= leaves per plant, TPP=tillers per plant, D50F= days to 50% flowering, TW= 100-seed weight, BYPP= biological per plant, D75M= days to 75% maturity, HI= harvest index.

D. Correlation and path analysis

Seed yield per plant showed a significant positive correlation (Fig. 1) with tillers per plant, harvest index, leaves per plant, plant height, 100-seed weight and days to 50% flowering. Selection for these traits might lead to yield enhancement. Correlation analysis for various characters revealed that selection for tallness, high harvest index, high 100-seed weight, high tillers and high number of leaves might enhance yield. Surprisingly 100-seed weight showed positive significant association with all the studied traits and days to 75% maturity showed a significant and strong positive correlation with days to 50% flowering, 100-seed weight and tillers per plant, validating that early flowering was correlated to early maturity. The maximum positive direct effect was exhibited by harvest index (0.855), which was sufficient to directly affect seed yield per plant while 100-seed weight had negative direct effect on seed yield per plant (Table 4). The positive correlation of days to 50% flowering, plant height, 100-seed weight, leaves per plant and tillers per plant with seed yield per plant was mainly due to indirect effect of harvest index, indicated that harvest index indirectly involve in seed yield enhancement. The residual effect of the path coefficient analysis was 0.131, indicating that the model fits poorly and not all the influencing characters on which seed yield per plant depends were covered. The findings match the previous researchers' study on the genetic variability in different oat populations (Kumar *et al*., 2022b).

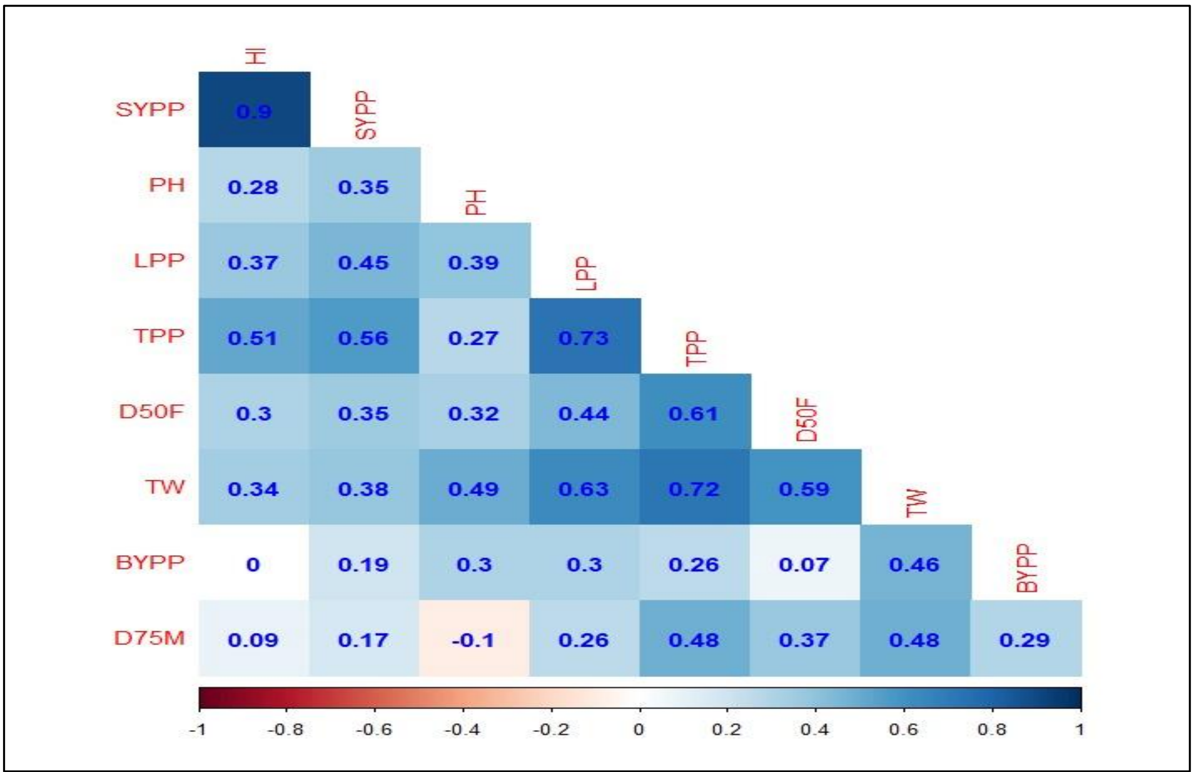

Fig. 2. Person correlation coefficient among yield and components traits. SYPP= seed yield per plant, PH= plant height, LPP= leaves per plant, TPP=tillers per plant, D50F= days to 50% flowering, TW= 100-seed weight, BYPP= biological per plant, D75M= days to 75% maturity, HI= harvest index.

Table 4: Direct and indirect effects on yield and component traits (R= 0.131).

Traits	D50F	PH	LPP	TPP	D75M	BYPP	HI	TW	SYPP
D50F	**0.081**	0.031	0.032	0.048	0.026	0.014	0.257	-0.138	0.35*
PH	0.026	**0.097**	0.028	0.021	-0.007	0.060	0.240	-0.114	0.35*
LPP	0.036	0.038	**0.072**	0.057	0.018	0.060	0.317	-0.147	0.45*
TPP	0.049	0.026	0.053	**0.078**	0.034	0.052	0.436	-0.168	0.56*
D75M	0.030	-0.010	0.019	0.037	**0.071**	0.058	0.077	-0.112	0.17
BYPP	0.006	0.029	0.022	0.020	0.021	**0.200**	0.000	-0.107	0.19
HI	0.024	0.027	0.027	0.040	0.006	0.000	**0.855**	-0.079	0.90**
TW	0.048	0.048	0.045	0.056	0.034	0.092	0.291	**-0.233**	0.38*

SYPP= seed yield per plant, PH= plant height, LPP= leaves per plant, TPP=tillers per plant, D50F= days to 50% flowering, TW= 100-seed weight, BYPP= biological per plant, D75M= days to 75% maturity, HI= harvest index.

CONCLUSIONS

The traits had genotypic and phenotypic coefficient of variation from low to high in backcross derived oat breeding lines. Among studied lines, three lines namely HJ-8-80-39-47-44, HJ-8-80-28-55-64 and HJ-8-80-36-78-67 exhibited superiority over recurrent parent HJ-8. Genotypes exhibited high heritability coupled with genetic advance as percent of the mean for seed yield per plant, harvest index, 100-seed weight, leaves per plant and tillers per plant, indicating selection may be effective for these traits. Partitioning of correlation showed that only harvest index, tillers per plant, leaves per plant and 100-seed weight could produce significant correlation with seed yield per which might be either due to very high direct or indirect effects. Hence, selection for these traits could bring improvement in yield and yield components.

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