Plant Archives Vol. 24, No. 2, 2024 pp. 1792-1798 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.257

GENETIC VARIABILITY, INTERRELATIONSHIP AND CAUSE - EFFECT ANALYSIS IN FODDER OATS UNDER MID HILL CONDITIONS OF UNION TERRITORY OF JAMMU & KASHMIR INDIA

Mahrukh[1], Praveen Singh[2], Khazin Hussain[1], R.S. Sudan[2*], Bupesh Kumar[2], Suheel Ahmad[3], V.B. Singh[2] and S.K. Rai[2]

[1]Division of Genetics and Plant Breeding, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, 193201, J&K, India.

[2]Division of Plant Breeding and Genetics, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, 180009, J & K, India.

[3]Regional Center IGFRI Srinagar, J & K, India.

*Corresponding author E-mail: rssudanudh@gmail.com

(Date of Receiving-12-05-2024; Date of Acceptance-24-07-2024)

ABSTRACT

Oat (*Avena sativa* L.) is an important winter cereal fodder crop of *Rabi* season in the U.T. of Jammu and Kashmir and the present study was aimed to ascertain the variability, interrelationship and cause and effect analysis among morpho-physiological, yield and quality traits in twenty-eight oat germplasm lines. The efficiency of selection can be broadened for certain traits using estimates of genetic variability parameters, thereby, increasing the efficiency of different breeding strategies to obtain genetic gains. Twenty-eight oat germplasm lines were evaluated during two consecutive years viz., *Rabi* 2018-2019 and *Rabi* 2019-2020 in a randomized complete block design with three replications. Data were collected on different morpho-physiological, yield and quality traits. The statistical analysis revealed that the germplasm lines differed significantly for all the traits. Crude protein, leaf stem ratio, dry matter yield, leaf area index and regeneration percentage reflected high heritability coupled with high genetic advance indicating that these parameters can be used for selection in oat breeding programs. Correlation and path coefficient analysis revealed that dry matter yield, leaf area index and leaf stem ratio had a highly significant positive and direct association with green fodder yield. Hence, selection based on such component traits may increase the green fodder yield in oat germplasm.

Introduction

The demand of Oat (*Avena sativa* L.) is increasing because of its wide range of adaptation, high nutritional value and multifarious uses including food for humans, feed for livestock and other value-added and industrial products.

The cultivated species are descended from the wild forms that were probably found as a weed in cultivated cereals in the Mediterranean region, Asia Minor, North Africa and Transcaucasia. Oat is distinct due to its multifunctional traits and nutritional profile. Recent advancement in food and nutrition has revealed the importance of its various components. Green fodder produced by oat contains about 10 to 13 per cent protein and 30 to 35 per cent dry matter. It is capable of giving a green fodder yield of 33.30-55.80 tonnes per hectare under the single-cut system, whereas it gives 40.80-41.60 tonnes per hectare under a multi-cut system in the Northwest zone of the country. Forage oats are grown in winter under a wide variety of soil and climatic conditions. Oat is an important winter fodder, mostly fed as green but surplus is converted into silage or hay to use during fodder deficit periods. Farmers face a shortage of green fodder during winters when there are only dry stalks of dry cereal fodders or dry summer grasses. Oat has a genetic potential to produce three-fold green fodder, that is, 60 to 80 tonnes per hectare and can feed a double number of animals per unit area as against the traditional fodder crops. Oats is a promising fodder crop due to its fast-growing nature, nutritive value and tolerance to salinity.

Considering the potentiality of fodder oats, there is a need for improvement and to develop varieties suited to specific agro-ecological conditions. Genetic variability is a major factor that determines prospects of yield improvement in future since they allow identifying the nature of the action of genes involved in the control of quantitative traits and evaluating the efficiency of different breeding strategies to obtain genetic gains. Parameters of genotypic and phenotypic coefficients of variation (GCV and PCV) are useful in detecting the variability present in the genotypes. Heritability and genetic advance to determine the influence of environment in expression of characters and the extent to which improvement is possible after selection. Crop improvement depends on the magnitude of genetic variability and the extent to which desirable characters are heritable. High heritability alone is not enough to make an efficient selection in segregating generation unless the information is accompanied by a substantial amount of genetic advance. The correlation estimated by the specific coefficient is important in plant breeding because it quantifies the degree of genetic and non-genetic association between two or more traits, allowing indirect selection. The path analysis justifies the existence of positive and negative correlations, high and low magnitudes among the studied traits. Knowledge of genetic variability within a crop and correlation among the yield contributing characters is essential for the long-term success of a breeding program and maximizes the exploration of germplasm resources. The objective of this study was to determine the genetic variations and associations among desired traits and their direct and indirect contributions towards green fodder yield.

Material and Methods

The experimental material consisted of 28 diverse genotypes collected from different centres of the country (Table 1). The experiment was conducted in randomized block design with three replication at the Research Farm of the Division of Plant Breeding and Genetics, SKUAST-J during Rabi seasons in two consecutive years 2018-2019 and 2019- 2020. Each treatment was sown in 4 rows each of 2 m length with 25 cm spacing between the rows. Data on different traits *viz;* plant height, leaf length, number of tillers per plant, dry matter yield, leaf width, number of leaves per plant, leaf area index, crude protein, stem girth, regeneration percentage, leaf stem ratio, days to 50 percent flowering, days to maturity and green fodder yield was recorded. Five competitive plants of each genotype per plot were randomly tagged. them days to flowering, days to maturity, green fodder yield, regeneration percentage and dry matter yield were recorded on the plot basis whereas for the rest of the traits data were recorded from an average of tagged plants only. The data collected for 2 years was averaged (Table 2) and subjected to analysis of variance to test the genotypic differences among the genotypes commonly applicable to the randomized block design as per method suggested by Panse and Sukhatme (1985). Heritability in broad sense was estimated as suggested by Hanson *et al.*, (1956). Genetic advance (at 5% selection intensity) was calculated using the formula given by Allard (1960). For calculating the genotypic and phenotypic correlation co-efficient for all possible combinations the formula suggested by Millar *et al.*, (1958) and Johnson *et al.*,

Table 1: List of all the oat genotypes evaluated in present study.

S.	Genotype	Source	Origin/pedigree
1	JHO 99-2	IGFRI, Jhansi	IGFRI, Jhansi
2	SKO 188	SKUAST-K	SKUAST-K
3	SKO 96	SKUAST-K	SKUAST-K
4	SKO 90	SKUAST-K	SKUAST, K
5	JHO 2000-4	IGFRI, Jhansi	A. sativa- JHO-851 × A. maroccana - 16/30
6	Sabzar	SKUAST, K	SKO2
7	JHO 88-2	IGFRI, Jhansi	IGFRI, Jhansi
8	SKO 98	SKUAST-K	SKUAST-K
9	JHO 99-1	IGFRI, Jhansi	OS7 × IGO 320-1139-19
10	SKO 20	SKUAST-K	EC-13178
11	JHO 855	IGFRI, Jhansi	IGFRI, Jhansi
12	JHO 822	IGFRI, Jhansi	IGO-4268 X Indio-6-5-1
13	Palampur 1	CSK HPKV, Palampur	Algerian variety
14	HJ 8	CCS HAU, Hisar	OS- 7 × S-3021 P15
15	OS 405	CCS HAU, Hisar	CCS HAU, Hisar
16	Kent (Check)	USA	Introduction EC (29050)
17	OS 377	CCS HAU, Hisar	HJ 8 x Kent
18.	OS 7	CCS HAU, Hisar	HFO 10 × HFO 55 P2
19	OS 403	CCS HAU, Hisar	CCS HAU, Hisar
20	JHO 857	IGFRI, Jhansi	Hiugo Karyokuro
21	HFO 114	CCS HAU, Hisar	germplasm line 37/14
22	Local 4	Rajouri	Rajouri
23	OS 424	CCS HAU, Hisar	CCS HAU, Hisar
24	OS 346	CCS HAU, Hisar	CCS HAU, Hisar
25	OS 6	CCS HAU, Hisar	HFO 10 × HFO 55 P2
26	Local 1	Poonch	Poonch
27	Local 2	Poonch	Poonch
28	Local 3	Rajouri	Rajouri

Table 2: Mean performance and range for different morpho-physiological and quality characters of oat genotypes.

S. No.	Genotypes	Plant Height (cm)	Leaf Length (cm)	No. of Tillers / Plant	Dry Matter Yield (Kg/ plot)	Leaf Width (cm)	No. of Leaves / Plant	Leaf Area Index	Crude Protein	Stem Girth (cm)	Regene-ration (%)	Leaf Stem Ratio	Days to 50% Flowe-ring	Days to Matu-rity	Green Fodder Yield (Kg/ plot)
1	JHO 99-2	93.93	35	12.07	1.42	1.65	76.17	11.86	8.49	2.5	48.33	0.16	100.33	141.33	6.18
2	SKO 188	82.6	31.53	11.65	1.06	1.47	73.78	9.14	8.86	2.22	48.33	0.48	107.67	148.67	5.21
3	SKO 96	84.93	39.53	11.73	0.76	1.51	70.4	11.27	9.8	2.09	53.33	0.51	105	146	5.6
4	SKO 90	60.15	28	8.3	0.87	1.55	49.8	5.75	7.98	1.94	45	0.38	104.33	145.33	4.14
5	JHO2000-4	102.83	44.27	12.07	1.66	1.74	80.7	16.69	11.7	2.11	48.33	0.45	97	138	8.28
6	SABZAR	94.73	46.2	11.5	1.29	1.71	84.37	17.83	7.3	2.14	45	0.53	101	142	6.8
7	JHO 88-2	102.07	41.63	14.97	1.54	1.81	100	20.29	10.44	2.37	46.67	0.53	101.67	142.67	8.26
8	SKO 98	79.95	30.1	9.3	1.06	1.71	65.1	9	18.49	2.04	53.33	0.55	111	152	5.26
9	JHO 99-1	91.9	39.97	13.03	1.3	1.81	86.83	16.79	12.09	2.09	41.67	0.47	103	144	6.74
10	SKO 20	87.07	40.45	11.8	1.22	1.65	78.67	14.11	6.95	1.78	43.33	0.35	99	140	6.68
11	JHO 855	83.53	32.8	11.1	0.65	1.48	66.6	8.73	8.53	1.91	40	0.32	101	142	3.62
12	JHO 822	85.5	41.63	8.95	0.66	1.38	53.7	8.25	10.24	1.67	63.33	0.32	99	140	3.42
13	Palampur 1	73.77	32.8	10.77	0.53	1.53	67.6	9.2	7.76	1.71	46.67	0.37	101	142	2.82
14	HJ 8	88.3	36.3	11.63	1.2	1.7	73.67	12.18	9.48	1.58	70	0.47	110.33	151.33	5.83
15	OS 405	89.87	43.8	11.5	1.07	1.6	72.87	13.7	6.58	2.07	43.33	0.33	101	142	6.14
16	Kent (check)	95.73	43.15	10.97	1.44	1.81	69.8	14.63	8.75	2.24	60	0.31	96	137	6.3
17	OS 377	96	39.85	11.73	1.35	1.9	70.4	14.29	12.85	2.1	43.33	0.37	101	142	6.57
18	OS 7	90.87	45.45	10.6	0.84	1.68	71.2	14.53	14.49	2.1	81.67	0.31	102	143	5.05
19	OS 403	101.97	48.01	12.97	1.61	1.8	81.9	18.8	8.05	1.97	51.67	0.51	103	144	7.76
20	JHO 857	94.8	47.4	12.73	1.24	1.78	80.27	18.12	14.03	2.11	35	0.3	102	143	6.74
21	HFO 114	81.3	35.3	11.3	0.85	1.55	71.33	10.47	9.12	2	80	0.31	103	144	4.18
22	Local 4	86.45	41.3	8.83	0.88	1.58	55.97	9.78	14.07	1.94	68.33	0.29	102.67	143.67	4.9
23	OS 424	88.1	33.8	11.5	0.96	1.48	72.53	9.65	14.85	1.89	45	0.35	100	141	4.76
24	OS 346	98.95	40.07	12.53	1.55	1.91	75.2	15.5	13.82	1.65	30	0.29	98	139	6.86
25	OS 6	115.63	40.63	13.07	1.41	1.77	83.17	16.13	15.61	1.86	30	0.46	96	137	7.08
26	Local 1	88.73	45.73	10.93	0.98	1.68	69.13	14.13	12.72	1.98	40	0.3	101.33	142.33	5.64
27	Local 2	87.43	42.27	10.93	1.25	1.6	69.13	12.31	8.88	1.91	33.33	0.26	101	142	6.07
28	Local 3	92.87	36.15	11	1.1	1.58	74	11.3	8.9	1.9	38.33	0.4	103	144	6.04
Range		60.15 - 115.63	28.00- 48.01	8.30- 14.97	0.53- 1.66	1.38- 1.91	49.80- 100.00	5.75- 20.29	6.58- 18.49	1.58- 2.50	30.00- 81.67	0.16- 0.55	96.00- 111.00	137.00- 152.00	2.82- 8.28
C.D at 5%		6.18	4.85	2.24	0.21	0.29	5.9	3.07	0.77	0.33	13.59	0.04	2.61	2.61	0.92
C.V		4.2	7.52	12.01	11.58	10.65	4.94	14.39	4.39	10.23	16.93	6.94	1.56	1.11	9.69

(1955) were adopted. Path co-efficient analysis was done according to the procedure employed by Wright (1921) and Dewey and Lu (1959). The statistical analysis was carried out by using computer software INDOSTAT 9.2.

Results and Discussion

The analysis of variance revealed significant differences among the genotypes for all characters studied indicating a high degree of variability in the material. Genetic parameters such as genotypic, phenotypic and environmental variance; genotypic, phenotypic and environmental coefficient of variation; broad sense heritability and genetic advance in percentage were analysed for all fourteen traits for twenty-eight genotypes (Table 3). The estimates of phenotypic variance were higher than the corresponding estimates of genotypic variance for all the traits except leaf stem ratio, indicating thereby, the influence of environment in the expression of these traits. Since these estimates solely do not provide means to assess the nature of genetic variability, phenotypic and genotypic coefficients of variation were also estimated. The highest genotypic coefficient of variation was recorded for crude protein (28.45) followed by leaf area index (27.01) and dry matter yield (26.08). Sizeable value of the genotypic coefficient of variation in respect of these traits indicated high genetic and very little environmental influence and thus these traits may be relied upon for the purpose of selection of phenotypic basis. The highest phenotypic coefficient of

Table 3: Genetic parameters of variability for different morpho-physiological and quality characters of oat genotypes.

Source of variation	Plant Height (cm)	Leaf Length (cm)	No. of Tillers / Plant	Dry Matter Yield (Kg/ plot)	Leaf Width (cm)	No. of Leaves / Plant	Leaf Area Index	Crude Protein	Stem Girth (cm)	Regene-ration (%)	Leaf Stem Ratio	Days to 50% Flowe-ring	Days to Matu-rity	Green Fodder Yield (Kg/ plot)
Genotypic Variance	100.53	26.41	1.36	0.09	0.01	98.88	12.36	9.34	0.03	157.14	0.01	11.93	11.93	1.80
Phenotypic Variance	114.80	35.18	3.24	0.10	0.04	111.86	15.87	9.57	0.07	226.10	0.01	14.47	14.47	2.12
Environmental Variance	14.27	8.77	1.88	0.02	0.03	12.99	3.51	0.22	0.04	68.96	0.00	2.54	2.54	0.32
PCV	11.91	15.06	15.77	28.53	12.05	14.49	30.60	28.79	13.41	30.66	26.34	3.74	2.66	25.01
GCV	11.14	13.05	10.22	26.08	5.63	13.62	27.01	28.45	8.66	25.56	25.41	3.39	2.42	23.06
ECV	4.20	7.52	12.01	11.58	10.65	4.94	14.39	4.39	10.23	16.93	6.94	1.56	1.12	9.69
h^2 (Broad Sense)	87.57	75.08	42.02	83.54	21.87	88.39	77.89	97.67	41.78	69.50	93.07	82.47	82.47	85.00
G.A as % of Mean 5%	21.48	23.29	13.65	49.10	5.43	26.38	49.11	57.92	11.54	43.89	50.50	6.35	4.52	43.79
G.A as % of Mean 1%	27.52	29.85	17.50	62.92	6.96	33.81	62.93	74.23	14.78	56.25	64.72	8.13	5.80	56.12
General Mean	90.00	39.39	11.41	1.13	1.66	73.01	13.02	10.74	1.99	49.05	0.38	101.83	142.83	5.82

variation was recorded for regeneration percentage (30.66) followed by leaf area index (30.60), crude protein (28.79) and dry matter yield (28.53) almost following the same trend suggesting thereby that the scope for improvement of these traits during selection could be based on phenotypic variability. The moderately high value of PCV and GCV has been reported in fodder oats for the number of tillers per plant (Dubey *et al.,* 2014a) and leaf length (Krishna *et al.,* 2013). Considerable low estimates of PCV and GCV were reported for days to 50 per cent flowering and days to maturity (Bind *et al.,* 2016; Dubey *et al.,* 2014a). The estimates of heritability act as a predictive instrument in expressing the reliability of phenotypic value. Therefore, high heritability helps in effective selection for a particular trait. The estimate of heritability for different traits studied ranged from 21.87 (leaf width) to 97.67 (crude protein). The results are in general agreement with the findings of other workers (Krishna *et al.,* 2013; Leišová- Svobodová *et al.,* 2019; Sahu and Tiwari, 2020). Heritability in conjunction with genetic advance would give a more reliable index of selection value (Johnson *et al.,* 1955). In the present study high heritability was coupled with high to medium genetic advance (as per cent of mean) in crude protein, leaf stem ratio, green fodder yield, dry matter yield, leaf area index and regeneration percentage. This indicated the scope for selection in these traits also reported by Bind *et al.,* 2016; Chauhan and Singh, 2019. Hence it indicated the predominance of additive gene action for controlling these characters. Therefore, these characters can be improved simply through selection. High heritability with low genetic advance was observed for days to maturity and days to 50 per cent flowering. It suggested non-additive gene action for the expressions of these characters. The high heritability was exhibited due to favourable influence of environment rather than genotype and selection for such traits might not be rewarding.

Selection based on the detailed knowledge of magnitude and direction of association between yield and its attributes is very important in identifying the key characters, which can be exploited for crop improvement through a suitable breeding programme. The correlation Coefficient for genotypic and phenotypic levels are presented in Table 4. Genotypic correlation coefficients were found higher than the phenotypic correlation coefficients in most of the cases except in crude protein which suggested that character association had not been largely influenced by environmental factors. There were highly significant and positive correlations of green fodder yield with leaf width, dry matter yield, leaf area index, number of tillers per plant, plant height and number of leaves per plant both at genotypic and phenotypic levels. These findings were in general agreement with the earlier reports of various workers (Bibi *et al.,* 2012; Ahmed *et al.,* 2013; Krishna *et al.,* 2014; Sahu and Tiwari, 2020). So, direct selection for the positively correlated characters will be helpful in the improvement of green fodder yield. High positive contribution shown by various characters might have a direct impact on fodder yield improvement (Ahmed *et al.,* 2013).

Table 4: Genotypic and phenotypic correlation coefficient among different morpho-physiological and quality characters of oat genotypes.

Traits		Plant Height (cm)	Leaf Length (cm)	No. of Tillers / Plant	Dry Matter Yield (Kg/ plot)	Leaf Width (cm)	No. of Leaves / Plant	Leaf Area Index	Crude Protein	Stem Girth (cm)	Regene-ration (%)	Leaf Stem Ratio	Days to 50% Flowe-ring	Days to Matu-rity	Green Fodder Yield (Kg/ plot)
Plant Height (cm)	G P	**2.21** **0.14**	-3.62 0.11	0.20 -0.01	-0.48 0.32	-2.60 0.06	-4.56 0.13	10.42 -0.04	-0.05 -0.01	0.02 0.01	0.07 0.02	-0.11 0.01	3511.28 -717.52	-3511.97 717.49	0.81** 0.71**
Leaf Length (cm)	G P	1.50 0.08	**-5.34** **0.20**	0.10 -0.01	-0.28 0.19	-1.94 0.04	-2.71 0.07	9.84 -0.04	-0.01 0.00	0.01 0.00	0.00 0.00	0.06 0.00	3238.07 -643.17	-3238.71 643.15	0.62** 0.51**
No. of Tillers /Plant	G P	1.86 0.08	-2.28 0.06	**0.24** **-0.02**	-0.49 0.24	-2.63 0.04	-6.85 0.15	11.51 -0.03	0.01 0.00	0.03 0.01	0.13 0.01	-0.27 0.02	1978.63 -267.43	-1979.02 267.42	0.87** 0.55**
Dry Matter Yield (Kg/ plot)	G P	1.71 0.10	-2.37 0.08	0.19 -0.01	**-0.62** **0.48**	-3.25 0.07	-4.45 0.12	9.91 -0.03	-0.01 0.00	0.03 0.01	0.10 0.02	-0.16 0.01	1884.18 -426.91	-1884.33 426.99	0.93** 0.92**
Leaf Width (cm)	G P	2.13 0.06	-3.84 0.06	0.23 -0.01	-0.75 0.26	**-2.69** **0.14**	-5.45 0.07	12.00 -0.04	-0.09 0.00	0.02 0.01	0.13 0.00	-0.21 0.01	1911.24 -240.49	-1911.62 240.48	0.99** 0.55**
No. of Leaves /Plant	G P	1.60 0.10	-2.29 0.07	0.26 -0.02	-0.44 0.29	-2.33 0.05	**-6.31** **0.19**	10.77 -0.04	0.00 0.00	0.03 0.02	0.08 0.02	-0.33 0.03	1245.41 -230.27	-1245.65 230.27	0.81** 0.70**
Leaf Area Index	G P	1.87 0.10	-4.26 0.15	0.22 -0.01	-0.50 0.33	-2.62 0.09	-5.52 0.15	**12.33** **-0.05**	-0.02 0.00	0.03 0.01	0.07 0.01	-0.21 0.02	2493.06 -505.21	-2493.55 505.19	0.91** 0.78**
Crude Protein	G P	0.58 0.04	-0.14 0.01	-0.01 0.00	-0.05 0.04	-1.25 0.03	0.10 0.00	1.01 0.00	**-0.19** **-0.02**	0.00 0.00	0.00 0.00	-0.06 0.01	-502.70 123.47	502.79 -123.47	0.08 0.09
Stem Girth (cm)	G P	0.62 0.02	-1.00 0.01	0.10 -0.01	-0.28 0.10	-0.71 0.03	-3.01 0.05	4.78 -0.01	0.01 0.00	**0.07** **0.06**	-0.01 0.00	-0.04 0.00	173.36 -52.02	-173.39 52.02	0.49** 0.25*
Regen-eration %	G P	-0.63 -0.03	0.06 -0.01	-0.13 0.00	0.24 -0.13	1.41 -0.01	2.06 -0.05	-3.64 0.01	0.00 0.00	0.00 0.00	**-0.25** **-0.08**	0.02 0.00	-2392.85 406.48	2393.32 -406.46	-0.40** -0.27*
Leaf Stem Ratio	G P	0.30 0.02	0.36 -0.01	0.08 0.00	-0.12 0.08	-0.69 0.02	-2.58 0.07	3.13 -0.01	-0.02 0.00	0.00 0.00	0.01 0.00	**-0.81** **0.09**	-3114.92 635.69	3115.58 -635.65	0.33** 0.29**
Days to 50 % Flowe-ring	G P	-1.14 -0.06	2.54 -0.08	-0.07 0.00	0.17 -0.13	0.76 -0.02	1.15 -0.03	-4.51 0.02	-0.01 0.00	0.00 0.00	-0.09 -0.02	-0.37 0.03	**-6809.69** **1630.43**	6811.03 -1630.37	-0.24* -0.22*
Days to Matu-rity	G P	-1.14 -0.06	2.54 -0.08	-0.07 0.00	0.17 -0.13	0.76 -0.02	1.15 -0.03	-4.51 0.02	-0.01 0.00	0.00 0.00	-0.09 -0.02	-0.37 0.03	-6809.69 1630.43	**6811.03** **-1630.37**	-0.24* -0.22*

As simple correlation does not provide the true contribution of the characters towards the yield, these genotypic correlations were partitioned into direct and indirect effects through path coefficient analysis. It allows separating the direct effect and their indirect effects through other attributes by apportioning the correlations

Table 5: Genotypic and phenotypic path coefficient for green fodder yield with different morpho-physiological and quality characters of oat genotypes.

Traits		Plant Height (cm)	Leaf Length (cm)	No. of Tillers / Plant	Dry Matter Yield (Kg/ plot)	Leaf Width (cm)	No. of Leaves / Plant	Leaf Area Index	Crude Protein	Stem Girth (cm)	Regene-ration (%)	Leaf Stem Ratio	Days to 50% Flowe-ring	Days to Matu-rity	Green Fodder Yield (Kg/ plot)
Plant Height (cm)	G P	1.00 1.00	0.68** 0.57**	0.84** 0.57**	0.77** 0.67**	0.96** 0.40**	0.72** 0.66**	0.85** 0.72**	0.26* 0.25*	0.28* 0.12	-0.29** -0.21	0.14 0.11	-0.52** -0.44**	-0.52** -0.44**	0.81** 0.71**
Leaf Length (cm)	G P		1.00 1.00	0.43** 0.31**	0.44** 0.39**	0.72** 0.28**	0.43** 0.36**	0.80** 0.75**	0.03 0.02	0.19 0.07	-0.01 -0.03	-0.07 -0.04	-0.48** -0.39**	-0.48** -0.39**	0.62** 0.51**
No. of Tillers /Plant	G P			1.00 1.00	0.79** 0.49**	0.98** 0.30**	1.08** 0.79**	0.93** 0.64**	-0.03 -0.04	0.40** 0.23*	-0.53** -0.19	0.33** 0.20	-0.29** -0.16	-0.29** -0.16	0.87** 0.55**
Dry Matter Yield (Kg/ plot)	G P				1.00 1.00	1.21** 0.54**	0.70** 0.60**	0.80** 0.68**	0.07 0.08	0.45** 0.21*	-0.38** -0.28*	0.20 0.16	-0.28* -0.26*	-0.28* -0.26*	0.93** 0.91**
Leaf Width (cm)	G P					1.00 1.00	0.86** 0.37**	0.97** 0.69**	0.46** 0.21	0.26* 0.19	-0.52** -0.04	0.26* 0.12	-0.28** -0.15	-0.28** -0.15	0.99** 0.55**
No. of Leaves /Plant	G P						1.00 1.00	0.87** 0.79**	-0.02 -0.02	0.48** 0.26*	-0.33** -0.24*	0.41** 0.36**	-0.18 -0.14	-0.18 -0.14	0.81** 0.70**
Leaf Area Index	G P							1.00 1.00	0.08 0.06	0.39** 0.23*	-0.29** -0.16	0.25* 0.23*	-0.37** -0.31**	-0.37** -0.31**	0.91** 0.78**
Crude Protein	G P								1.00 1.00	-0.06 -0.03	0.00 0.00	0.08 0.07	0.07 0.08	0.07 0.08	0.08 0.09
Stem Girth (cm)	G P									1.00 1.00	0.04 0.01	0.05 0.01	-0.03 -0.03	-0.03 -0.03	0.49** 0.25*
Regen-eration %	G P										1.00 1.00	-0.02 -0.02	0.35** 0.25*	0.35** 0.25*	-0.40** -0.27*
Leaf Stem Ratio	G P											1.00 1.00	0.46** 0.39**	0.46** 0.39**	0.33** 0.29**
Days to 50 % Flowe-ring	G P												1.00 1.00	1.00** 1.00**	-0.24* -0.22*
Days to Matu-rity	G P													1.00 1.00	-0.24* -0.22*

(Wright, 1921) for better interpretation of the cause and effect relationship. Path Analysis has been presented in Table 5. The maximum positive direct effect on green fodder yield per plot was exhibited by leaf area index (12.33), followed by plant height (2.21), days to maturity (2.03), number of tillers per plant (0.24) and stem girth (0.07). The maximum negative direct effects on green fodder yield per plot was exhibited by number of leaves per plant, leaf length, leaf width and leaf stem ratio. The results found were almost in confirmation with the earlier results of Ahmad *et al.*, 2013; Krishna *et al.*, 2014. Hence, direct selection for these traits could be practised for developing high green fodder yield oat genotypes.

Conclusion

In this study all the oat genotypes significantly differed for all the characters under study indicating sufficient amount of genetic variation present in the genotypes. From the results based on mean performance and genetic variability it can be concluded that the genotypes; JHO 2000-4, JHO 88-2, OS 403, OS 6 and OS 346 were found promising for one or more characters. The estimation of genetic parameters, correlation and path coefficient of some promising oat genotypes for green fodder yield and yield contributing characters indicated that in crude protein, leaf stem ratio, dry matter yield, leaf area index and regeneration percentage had high both genotypic and phenotypic variance with high heritability and high genetic advance. Dry matter yield, leaf area index and leaf stem ratio had the highest genotypic and phenotypic correlation coefficient on yield. Crude protein exhibited positive but non-significant correlation but regeneration percentage exhibited significant and negative correlation coefficient. Hence these four important traits *i.e*; leaf stem ratio, dry matter yield, leaf area index and regeneration percentage could be considered as selection criteria for the development of high green fodder yielding oat varieties for mid hill conditions of Jammu and Kashmir. It would therefore, be productive to lay stress on these characters in hybridization program for further improvement of green fodder yield and related characters in oats.

References

Allard, R.W. (1960). Principles of Plant Breeding. John Willy and Sons Inc., USA.

Ahmed, S., Roy A.K. and Majumdar A.B. (2013). Correlation and path coefficient analysis for fodder and grain yield related traits in oats (*Avena sativa* L.). *Annals of Biology*, **29**, 75-78.

Bibi, A., Shahzad A.N., Sadaqat H.A., Tahir M.H.N. and Fatima B. (2012). Genetic characterization and inheritance studies of oats (*Avena sativa*) for green fodder yield. *International Journal Biology Pharmacy and Allied Science,* **1(4)**, 450-60.

Bind, H., Bharti B., Pandey M.K., Kumar S., Vishwanath and Kerkhi S.A. (2016). Genetic variability, heritability and genetic advance studies for different characters on green fodder yield in oat (*Avena sativa* L.). *Agricultural Science Digest,* **36(2)**, 88-91.

Chauhan, C., and Singh S.K. (2019). Genetic variability, heritability and genetic advance studies in oat (*Avena sativa* L.). *International Journal of Chemical Studies*, **7(1)**, 992-994.

Dewey, J. R. and Lu K.H. (1959). Correlation and path coefficient analysis of components of crested wheatgrass seed production. *Agronomy Journal*, **51**, 515-518.

Dubey, N., Avinashe H.A., Jaiwar J. and Chichkhede L. (2014). Estimates of genetic variability, heritability and genetic advance of oat (*Avena sativa* L.) genotypes for green fodder yield. *Electronic Journal of Plant Breeding*, **5(4)**, 881-883.

Hanson, C.H., Robinson H.F. and Comstock R.E. (1956). Biometrical studies of yield in segregating population of Korean lespedza. *Agronomy Journal,* **48**, 268-272.

Hussain, A., Muhammad D., Khan S. and Bhatti M.B. (1993). Forage yield and quality potential of various cultivars of oats (*Avena sativa* L.). *Pakistan Journal of Scientific and Industrial Research*, **36(6-7)**, 258-260.

Johnson, H.W., Robinson H.F. and Comstock R.E. (1955). Estimation of genetic and environmental variability in soybean. *Agronomy Journal*, **47(7)**, 314-317.

Krishna, A., Ahmed S., Pandey H.C. and Bahukhandi D. (2013). Estimates of genetic variability, heritability and genetic advance of oat (*Avena sativa* L.) genotypes for grain and fodder yield. *Agricultural Science Research Journals*, **3(2)**, 56-61.

Krishna, A., Ahmed S., Pandey H.C. and Kumar V. (2014). Correlation, path and diversity analysis of oat (*Avena Sativa* L.) genotypes for grain and fodder yield. *Journal of Plant Science & Research*, **1(2)**, 1-9.

Leišová-Svobodová, L., Michel S., Tamm I., Chourová M., Janovska D. and Grausgruber H. (2019). Diversity and Pre-Breeding Prospects for Local Adaptation in Oat Genetic Resources**.** *Sustainability,* **11(24)**, 6950.

Millar, P.A., Williams J.C., Robinson H. F. and Comstock R.E. (1958). Estimates of genotypic and environmental variance and covariance and their implication in selection. *Agronomy Journal*, **50**, 126-131.

Panse, V.G. and Sukhatme P.V. (1985). Statistical Methods for Agricultural Workers. New Delhi: ICAR.

Sahu, M. and Tiwari A. (2020). Genetic variability and association analysis of oat (*Avena sativa* L.) genotypes for green forage yield and other components. *Current Journal of Applied Science and Technology*, **39(17)**, 133-141.

Wright, S. (1921). Correlation and causation. *Journal of Agricultural Research*, **20**, 557-85.