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VARIABILITY PATTERN AND ITS DISTRIBUTION AMONG GERMPLASM ACCESSION OF OAT (*AVENA SP.* L.)

MAYURI SAHU[2], NEHA BELSARIYA[1]*, ANJALI KAK[3] AND SUJIT[4]

[1,2&4] Department of Genetics and Plant Breeding, COA, IGKV, Raipur-492 012 (Chhattisgarh), India
[3] Division of Germplasm Conservation, National Bureau of Plant Genetic Resources
(e-mail: nehabelsariya@gmail.com)

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SUMMARY

The present study on variability and character association in fodder oat was carried out at Research cum Instructional Farm, IGKV, Department of Genetics & Plant Breeding, Raipur during *Rabi*, 2019-20. An experiment was conducted with 294 germplasm accession belonging to ten different *Avena* species with six check varieties of oat (*Avena sp.* L.) in augmented design. Nineteen quantitative traits were studied for the assessment of genetic variability. Sufficient variation was exhibited by most of the traits studied. The highest values for GCV and PCV was green fodder yield, number of tillers per plant and number of leaves per plant. High heritability and coupled with high genetic advance were found in number of leaves per plant and green fodder yield per plant. Most of the traits studied had skewness value ranged from (-0.5 to 0.5) are normally distributed except for days to 50% flowering, number of tillers per plant, number of leaves of per plant, leaf dry weight per plant, leaf: stem ratio and days to maturity. Negative kurtosis (Platykurtic) *viz.,* leaf length, culm diameter, number of leaves per plant, seed yield per plant, dry matter weight and 1000 seed weight.

Keywords: Oat, genetic variability, correlation coefficients and heritability

Oat (*Avena sativa* L.) is a multipurpose cereal crop grown in rabi season in many parts of the world. In India, it is used as green fodder, hay and silage for animals. It has excellent growth habit, quick recovery after cutting and provides good quality herbage. Furthermore, the demand for oat for human consumption has increased, particularly because of the demonstrated dietary benefits of oat whole-grain products. Green fodder production for animals to provide balanced nutrition (Phogat *et al.,* 2021). Oat is considered to be a nutritious source of protein, carbohydrate, fibre, vitamins, and minerals as well as of compounds with beneficial effects on health. Assessment of the genetic variability can be achieved using morphological measurements and phenotypic characterization. Very good information on sources of germplasm, various descriptors, data on various morphological traits and characterization of oat germplasm on the basis of morphological traits has been well documented (Choubey *et al.,* 2005). The genotypic correlation between yield and yield attributing characters as well as path coefficient analysis are important in breeding programme. For selection programme, it is essential to have thorough knowledge about the mutual relationship among the yield and its component characters which are positively correlated. When a greater number of variables is considered, the association becomes more and more complex. Under such situations path coefficients would be more useful for calculating direct and indirect associations with yield. Therefore, the present study was undertaken in fodder oat to gather information on different parameters of genetic variability and association of component traits with fodder yield.

MATERIALS AND METHODS

The present study was carried out during *Rabi*, 2019 at Research cum instructional farm, Department of Genetics and Plant Breeding, IGKV, Raipur Chhattisgarh. A total of 294 genotypes procured from NBPGR, Delhi is presented in (Table 2) was evaluated under field condition using augmented design. The observations were recorded for 19 oat traits viz., days to 50% flowering, plant height (cm), number of leaves per plant, flag leaf length (cm), flag leaf width (cm), leaf length (cm), leaf width (cm), culm diameter (cm), number of nodes on the main culm, number of tillers per plant, peduncle length (cm), green) fodder yield (g), dry matter yield per plant (g), leaf dry weight per plant (g), stem dry weight per plant (g), leaf: stem ratio, days to maturity, seed yield

TABLE 1
Descriptor of Avena sativa L. (Oat)

S. No.	Characteristic	Class	Score
1.	Plant Vigour	Poor Good Very Good	1 2 3
2.	Growth Habit	Erect Semi-prostate Prostate Other (specify)	1 2 3 9
10.	Leaf Colour	Green Dark Green Other (specify)	1 2 9
11.	Leaf Sheath pubescence	Absent Present	0 1
12.	Flag leaf attitude	Erect Drooping Semi-drooping	1 2 9
13.	Stem Solidness	Hollow Semi Solid Solid	1 2 3
14.	Culm diameter (cm)	Quantitative	
15.	Number of nodes on the main culm	Quantitative	
16.	Number of tillers per plant	Quantitative	
17.	Peduncle length (cm)	Quantitative	
18.	Green fodder yield per plant (kg or g)	Quantitative	
19.	Dry matter yield per plant (kg or g)	Quantitative	
20.	Leaf dry weight per plant (g)	Quantitative	
21.	Stem dry weight per plant (g)	Quantitative	
22.	Leaf: stem ratio	Quantitative	
24.	Days to maturity	Quantitative	
25.	Panicle Attitude	Compact Semi-compact Lateral Equilateral Other (specify)	1 2 3 4 9
26.	Awn per spikelet	Absent One Two	0 1 2
27.	Primary Floret Pubescence	Absent Present	0 1
28.	Spikelet shattering	Shattering Non-shattering	1 2
29.	Hullness	Absent Present	0 10
30.	Seed yield per plant (g)	Quantitative	
31.	1000 seed weight (g)	Quantitative	
32.	Seed colour	White Yellow Grey Black Other (specify)	1 2 3 4 9
33.	Biotic Stress susceptibility	Very Low Low Intermediate High Very High	1 3 5 7 9

per plant (g) and 1000 seed weight (g) were studied which is received from Indian Grassland and Fodder Research Institute, Jhansi are presented in (Table 1). The descriptive statistics were worked out. The estimates of variability parameters were worked out according to the method suggested by Lush (1940). Phenotypic and genotypic coefficients of variation were calculated based on the method advocated by Burton (1952). Heritability in broad sense was estimated (Allard, 1960) and expressed in percentage. Genetic advance as per cent of mean was estimated by the method suggested by Johnson *et al.* (1955). Correlation coefficients between green fodder yield and its component traits were used for this analysis. By keeping green fodder yield as a dependent variable and the other traits as independent variables, simultaneous equations, which expressed the basic relationship between path coefficients, were solved to estimate the direct and indirect effects.

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance was carried out for 19 characters. There is considerable amount of variability present among the genotype studied are presented in the Table Analysis of variance revealed that most of studied were found significant at 1% and 5% level of significance. Trait like plant height, flag leaf length, flag leaf width, leaf length, leaf width, culm diameter, number of nodes per plant, peduncle length, green fodder yield and seed yield per plant were significant at 1% level of significance are observed in (Table-3). The above investigation pressed indicated better opportunity for a breeder to select a genotype for these traits.

MEAN, RANGE AND CV

Descriptive statistical analysis of the recorded characters like mean, minimum, maximum, standard deviation and coefficient of variation (CV) for green fodder yield and different quantitative traits are shown in the (Table 4). Days to 50% flowering showed a range of 66 to 103 with a mean of 81.29. The accession EC0130646 was found to be very early. all quantitative characters exhibited variability evident by high CV observed in most of the traits studied. The high CV observed among morphological characters which include leaf dry weight per plant (gm) (44.58%) followed by L:S ratio (41.83%), green fodder yield (gm) (34.57%), seed yield per plant (gm) (24.11%), number of tillers per plant (23.55%), dry matter yield per plant (gm) (23.14%), stem dry weight per plant (gm) (22.8%), number of leaves per plant (21.5%) is a clear indication of a high level of variability.

Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation

The estimates of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2, BS) and genetic

TABLE 2
List of genotypes of oat used in the study

S. No.	Botanical name	Accession	Country Name	S. No.	Botanical name	Accession	Country Name	S. No.	Botanical name	Accession	Country Name
1.	Avena sativa	EC0108120	ARGENTINA	43.	Avena sativa	EC0841794	SWEDEN	85.	Avena sativa	EC0108648	AUSTRALIA
2.	Avena sativa	EC0108122	ARGENTINA	44.	Avena sativa	EC0841793	SWEDEN	86.	Avena sterilis	EC0130450	CANADA
3.	Avena sativa	EC0108124	ARGENTINA	45.	Avena sativa	EC0841791	SWEDEN	87.	Avena sativa	EC0178760	CANADA
4.	Avena sativa	EC0108125	ARGENTINA	46.	Avena sativa	EC0841790	SWEDEN	88.	Avena sativa	EC0176071	CANADA
5.	Avena sativa	EC0108126	ARGENTINA	47.	Avena sativa	EC0841789	SWEDEN	89.	Avena sativa	EC0109263	CANADA
6.	Avena sativa	EC0246122	BRAZIL	48.	Avena sativa	EC0841788	SWEDEN	90.	Avena sativa	EC0109243	CANADA
7.	Avena sativa	EC0246131	BRAZIL	49.	Avena sativa	EC0841787	SWEDEN	91.	Avena sativa	EC0109104	CANADA
8.	Avena sativa	EC0246132	BRAZIL	50.	Avena sativa	EC0841785	SWEDEN	92.	Avena sativa	EC0092887	CANADA
9.	Avena sativa	EC0246134	BRAZIL	51.	Avena sativa	EC0006715	SWEDEN	93.	Avena sativa	EC0043840	CANADA
10.	Avena sativa	EC0246144	BRAZIL	52.	Avena sativa	EC0013354	SWEDEN	94.	Avena sativa	EC0112034	CANADA
11.	Avena sativa	EC0246145	BRAZIL	53.	Avena sativa	EC0013351	SWEDEN	95.	Avena sativa	EC0109262	CANADA
12.	Avena sterilis	EC0062320	NORWAY	54.	Avena sativa	EC0004721	FRANCE	96.	Avena sativa	EC0178759	CANADA
13.	Avena sativa	EC0057332	FINLAND	55.	Avena sativa	EC0003230	CYPRUS	97	Avena sativa	EC0178761	CANADA
14.	Avena sativa	EC0057333	FINLAND	56.	Avena sativa	EC0007815	YUGOSLAVIA	98.	Avena sativa	EC0140899	CANADA
15.	Avena sativa	EC0099174	PORTUGAL	57.	Avena byzantina	IC0282934	UTTARAKHAND	99.	Avena sativa	EC0117407	AUSTRALIA
16.	Avena byzantina	EC0099164	PORTUGAL	58.	Avena sativa	EC0246149	BRAZIL	100.	Avena sativa	EC0117404	AUSTRALIA
17	Avena byzantina	EC0099163	PORTUGAL	59.	Avena sativa	EC0246148	BRAZIL	101.	Avena sativa	EC0114246	AUSTRALIA
18.	Avena sativa	EC0099178	PORTUGAL	60.	Avena sativa	EC0246150	BRAZIL	102.	Avena sativa	EC0108657	AUSTRALIA
19.	Avena sativa	EC0099175	PORTUGAL	61.	Avena sterilis	EC0013183	CANADA	103.	Avena sativa	EC0055192	AUSTRALIA
20.	Avena sativa	EC0099170	PORTUGAL	62.	Avena sativa	EC0109261	CANADA	104.	Avena sativa	EC0004453	AUSTRALIA
21.	Avena byzantina	EC0099161	PORTUGAL	63.	Avena sativa	EC0113921	AUSTRALIA	105.	Avena sativa	EC0004456	AUSTRALIA
22.	Avena sativa	EC0007814	YUGOSLAVIA	64.	Avena byzantina	EC0015550	GERMANY	106.	Avena sativa	EC0007662	AUSTRALIA
23.	Avena sativa	EC0054834	ISRAEL	65.	Avena byzantina	EC0108724	ISRAEL	107.	Avena sativa	EC0008370	AUSTRALIA
24.	Avena sativa	EC0095143	CHILE	66.	Avena byzantina	EC0099165	PORTUGAL	108.	Avena sativa	EC0061704	UK
25.	Avena sativa	EC0096459	NEW ZEALAND	67.	Avena sativa	EC0054937	NEW ZEALAND	109.	Avena sativa	EC0108588	UK
26.	Avena sativa	EC0112078	ECUADOR	68.	Avena sterilis	EC0013594	AUSTRALIA	110.	Avena sativa	EC0108601	UK
27.	Avena sativa	EC0112079	ECUADOR	69.	Avena sativa	EC0004438	AUSTRALIA	111.	Avena sativa	EC0108604	UK
28.	Avena sativa	EC0157669	JAPAN	70.	Avena sativa	EC0008367	AUSTRALIA	112.	Avena sativa	EC0108602	UK
29.	Avena sativa	EC0030247	RUSSIA	71.	Avena sativa	EC0008369	AUSTRALIA	113.	Avena sativa	EC0107538	AUSTRALIA
30.	Avena sativa	EC0030244	RUSSIA	72.	Avena sativa	EC0086444	AUSTRALIA	114.	Avena sativa	EC0107536	AUSTRALIA
31.	Avena sativa	EC0159072	FINLAND	73.	Avena sativa	EC0056175	AUSTRALIA	115.	Avena sativa	EC0107534	AUSTRALIA
32.	Avena sativa	EC0159073	FINLAND	74.	Avena sativa	EC0057341	AUSTRALIA	116.	Avena sativa	EC0160165	AUSTRALIA
33.	Avena sativa	EC0159069	FINLAND	75.	Avena sativa	EC0055197	AUSTRALIA	117.	Avena sativa	EC0029050	AUSTRALIA
34.	Avena sativa	EC0067153	SWEDEN	76.	Avena sativa	EC0107533	AUSTRALIA	118.	Avena sativa	EC0102653	AUSTRALIA
35.	Avena sativa	EC0028808	SWEDEN	77.	Avena sativa	EC0103929	AUSTRALIA	119.	Avena sativa	EC0102652	AUSTRALIA
36.	Avena sativa	EC0028814	SWEDEN	78.	Avena sativa	EC0102649	AUSTRALIA	120.	Avena sativa	EC0019711	AUSTRALIA

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Table 2 contd...

37.	Avena sativa	EC0028817	SWEDEN	79.	Avena sativa	EC0114385	AUSTRALIA	121.	Avena sativa	EC0108654	AUSTRALIA
38.	Avena sativa	EC0025140	SWEDEN	80.	Avena sativa	EC0108660	AUSTRALIA	122.	Avena sativa	EC0108650	AUSTRALIA
39.	Avena sativa	EC0028815	SWEDEN	81.	Avena sativa	EC0108659	AUSTRALIA	123.	Avena sativa	EC0004451	AUSTRALIA
40.	Avena sativa	EC0028804	SWEDEN	82.	Avena sativa	EC0108656	AUSTRALIA	124.	Avena sativa	EC0030248	
41.	Avena sativa	EC0841796	SWEDEN	83.	Avena sativa	EC0108652	AUSTRALIA	125.	Avena sativa	EC0029049	AUSTRALIA
42.	Avena sativa	EC0841795	SWEDEN	84.	Avena sativa	EC01s08651	AUSTRALIA	126.	Avena sterilis	EC0062355	UK
127.	Avena sativa	EC0108600	UK	167.	Avena sterilis	EC0130643	USA	207.	Avena sativa	EC0310505	USA
128.	Avena sativa	EC0108599	UK	168.	Avena sterilis	EC0130641	USA	208.	Avena sativa	EC0179873	USA
129.	Avena sativa	EC0108593	UK	169.	Avena sterilis	EC0130639	USA	209.	Avena sativa	EC0182974	USA
130.	Avena sativa	EC0108587	UK	170.	Avena sativa	EC0159067	USA	210.	Avena sativa	EC0100750	USA
131.	Avena sativa	EC0108586	UK	171.	Avena sativa	EC0130648	USA	211.	Avena sativa	EC0099357	USA
132.	Avena sativa	EC0108603	UK	172.	Avena sativa	EC0130646	USA	212.	Avena sativa	EC0099353	USA
133.	Avena sativa	EC0024900	UK	173.	Avena byzantina	EC0131300	USA	213.	Avena sativa	EC0022034	USA
134.	Avena brevis	EC0032557	UK	174.	Avena sativa	EC0310504	USA	214.	Avena sativa	EC0022031	USA
135.	Avena sativa	EC0055196	AUSTRALIA	175.	Avena sterilis	EC0039403	USA	215.	Avena sativa	EC0095144	CHILE
136.	Avena sativa	EC0029051	AUSTRALIA	176.	Avena sativa	EC0043583	USA	216.	Avena sativa	EC0095707	USA
137.	Avena sativa	EC0143511	AUSTRALIA	177.	Avena sativa	EC0043556	USA	217.	Avena sativa	EC0095708	USA
138.	Avena sativa	EC0029055	AUSTRALIA	178.	Avena sativa	OL-1896	Punjab	218.	Avena sativa	EC0095832	USA
139.	Avena sativa	EC0029053	AUSTRALIA	179.	Avena fatua	EC0537815	USA	219.	Avena sativa	EC0096530	USA
140.	Avena sativa	EC0117406	AUSTRALIA	180.	Avena sativa	HFO-718	Haryana	220.	Avena sativa	EC0096531	USA
141.	Avena sativa	EC0107532	AUSTRALIA	181.	Avena brevis	EC0537806	USA	221.	Avena sativa	EC0096534	USA
142.	Avena sativa	EC0029058	AUSTRALIA	182.	Avena brevis	EC0537805	USA	222.	Avena sativa	EC0110313	USA
143.	Avena sativa	EC0096533	USA	183.	Avena abyssinica	EC0537798	USA	223.	Avena sterilis	EC0108477	USA
144.	Avena sativa	EC0096577	USA	184.	Avena sativa	EC0022041	USA	224.	Avena sativa	EC0140867	USA
145.	Avena sativa	EC0029057	AUSTRALIA	185.	Avena sativa	EC0022025	USA	225.	Avena sativa	EC0107021	USA
146.	Avena sativa	EC0107531	AUSTRALIA	186.	Avena sativa	EC0022023	USA	226.	Avena sativa	EC0104492	USA
147.	Avena sativa	EC0107530	AUSTRALIA	187.	Avena sativa	EC0022019	USA	227.	Avena sativa	EC0104483	USA
148.	Avena sativa	EC0096537	USA	188.	Avena sativa	EC0022017	USA	228.	Avena sativa	EC0103202	USA
149.	Avena sativa	EC0096540	USA	189.	Avena sativa	EC0022012	USA	229.	Avena sativa	EC0102353	USA
150.	Avena sativa	EC0096536	USA	190.	Avena sativa	EC0022009	USA	230	Avena sativa	EC0102347	USA
151.	Avena sativa	EC0096583	USA	191.	Avena sativa	EC0104486	USA	231.	Avena sativa	EC0102345	USA
152.	Avena longiglumis	EC0537819	USA	192.	Avena sativa	EC0104485	USA	232.	Avena sativa	EC0102333	USA
153.	Avena sativa	EC0179872	USA	193	Avena sativa	EC0104012	USA	233.	Avena sativa	EC0100753	USA
154.	Avena sativa	EC0005681	USA	194	Avena sativa	EC0104007	USA	234.	Avena strigosa	EC0108483	USA
155.	Avena sativa	EC0035137	HUNGARY	195.	Avena sativa	EC0104006	USA	235.	Avena sativa	EC0114256	USA
156.	Avena sativa	EC0035131	HUNGARY	196.	Avena sativa	EC0104004	USA	236.	Avena sativa	OS-6	Haryana
157.	Avena sativa	EC0035114	HUNGARY	197.	Avena sativa	EC0104003	USA	237.	Avena sativa	EC0528864	USA
158.	Avena sativa	EC0035144	HUNGARY	198.	Avena sativa	EC0102354	USA	238.	Avena eriantha	EC0537811	USA
159.	Avena sativa	EC0104475	USA	199.	Avena sativa	EC0102348	USA	239.	Avena brevis	EC0537809	USA
160.	Avena sativa	EC0005853	USA	200.	Avena sativa	EC0102342	USA	240.	Avena brevis	EC0537808	USA
161.	Avena sativa	EC0107022	USA	201.	Avena sativa	EC0102337	USA	241.	Avena abyssinica	EC0537800	USA

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Table 2 cont...

162.	Avena abyssinica	EC0108432	USA	202.	Avena sativa	EC0102331	USA	242.	Avena strigosa	EC0108485	USA
163.	Avena sativa	EC0102008	USA	203.	Avena sativa	EC0310508	USA	243.	Avena magna	EC0108466	USA
164.	Avena sativa	EC0179874	USA	204.	Avena sativa	EC0310510	USA	244.	Avena byzantina	EC0108451	USA
165.	Avena sativa	EC0159548	USA	205.	Avena sativa	EC0310507	USA	245.	Avena abyssinica	EC0108436	USA
166.	Avena sterilis	EC0131306	USA	206.	Avena sativa	EC0310506	USA	246.	Avena byzantina	EC0108448	USA
247.	Avena sterilis	EC0039402	USA	271.	Avena sativa	EC0096586	USA				
248.	Avena sativa	EC0057662	USA	272.	Avena abyssinica	EC0108435	USA				
249.	Avena sativa	EC0043555	USA	273.	Avena abyssinica	EC0108434	USA				
250.	Avena sativa	EC0022026	USA	274.	Avena sativa	EC0005677	USA				
251.	Avena sativa	EC0130635	USA	275.	Avena sativa	EC0005680	USA				
252.	Avena sativa	EC0130633	USA	276.	Avena sativa	EC0005854	USA				
253.	Avena sativa	EC0114547	USA	277.	Avena sativa	EC0005906	USA				
254.	Avena sativa	EC0096580	USA	278.	Avena sterilis	EC0008287	USA				
255.	Avena sativa	EC0096578	USA	279.	Avena sativa	EC0057661	USA				
256.	Avena sativa	EC0096539	USA	280.	Avena sativa	EC0093065	USA				
257.	Avena sativa	EC0096529	USA	281.	Avena sativa	EC0209260	USA				
258.	Avena sativa	EC0093069	USA	282.	Avena sativa	EC0043665	USA				
259.	Avena sativa	EC0093066	USA	283.	Avena sativa	EC0043586	USA				
260.	Avena sativa	EC0067316	USA	284.	Avena sterilis	EC0039915	USA				
261.	Avena sativa	EC0102011	USA	285.	Avena sativa	EC0209213	USA				
262.	Avena sativa	EC0528874	USA	286.	Avena sterilis	EC0131305	USA				
263.	Avena sativa	EC0528871	USA	287.	Avena sativa	EC0093068	USA				
264.	Avena sativa	EC0106148	USA	288.	Avena sativa	EC0209198	USA				
265.	Avena sativa	EC0100754	USA	289	Avena sativa	RO-19	MH				
266.	Avena sativa	EC0100752	USA	290	Avena sativa	JHO-822	UP				
267.	Avena sativa	EC0099358	USA	291	Avena sativa	OS-405	Haryana				
268.	Avena sativa	EC0096846	USA	292	Avena sativa	J0-1	MP				
269.	Avena sativa	EC0096589	USA	293	Avena sativa	JHO-851	UP				
270.	Avena sativa	EC0096588	USA	294	Avena sativa	UPO-12-1	Uttarakhand				

Source: Procured from NBPGR (National Bureau of Plant Genetic Resources).

advance as per cent of mean (GA) are presented in (Table 5). Highest estimated GCV and PCV was observed for number of leaves per plant, number of tillers per plant and green fodder yield per plant. Number of leaves per plant showed range of 9.80 to 78.17 with mean 38.63. The accession EC0095144 was found to be more no. of leaves. Number of tillers per plant showed range of 2.60 to 16 with mean 7.7. The accession EC0099165 was found to be more tillers. Green fodder yield per plant showed range of 32.20 to 229 with mean 92.79. The accession EC0004721 was found to be more green fodder. So, by selecting these traits would provide a good scope for crop improvement, Chakraborty *et al.* 2014 and Chouhan and Singh, 2019 also found high GCV and PCV for seed yield per plant.

Heritability and genetic advance

The success in any breeding programme depends on the spectrum of genetic variability present in the germplasm. A survey of genetic variability is essentially the first step in crop improvement and plant breeding is an exercise in the management of variability (Hutchinson, 1958). Heritability indicates the accuracy with which a genotype can be identified by its phenotypic performance. High heritability combined with high genetic advance in the indication of additive gene action and selection based on this would be more effective. High heritability and high genetic advance were found in number of leaves per plant and green fodder yield per plant. Sangwan *et. al.* (2012) observed high heritability with high genetic advance for tillers per plant and green fodder yield.

SKEWNESS AND KURTOSIS

The magnitude and frequency of such variants might be more in one or the other direction or be equal in both directions. A comparison of the distribution parameters like skewness and kurtosis would give a clearer picture of the extent of variability induced in the traits. Skewness and kurtosis indicate relative mean performance and nature of distribution of traits. If value ranges from -0.5 to 0.5 then the data is normally distributed i.e., symmetrical. Kurtosis indicates the peak ness or flatness of a tail of a curve. If the value is near (? = 3) then the data is normally distributed

TABLE 3

Analysis of variance for green fodder yield and its attributing traits in oat (Avena sativa sp.)

Source of variation	Degree of freedom	Days to% 50 flowering	Plant height	Flag leaf length	Flag leaf width	Leaf length	Leaf width	Culm diameter	No. of nodes/ plant	No. of tillers/ plant	No. of leaves/ plant
Block (ignoring treatments	5	400 **	230.95**	123.577**	0.31**	160.98**	0.16**	0.155**	0.653*	104.58**	7,550.64**
Treatments (eliminating blocks)	293	62.04 *	111.24**	23.4*	0.06**	38.1**	0.03	0.007	0.364	4.575	107.444
Blocks (eliminating treatments)	5	7.985	16.78	20.67	0.053**	13.95	0.07*	0.023**	0.053	3.695	49.273
Treatment (ignoring blocks)	293	68.73**	114.89**	25.15*	0.064**	40.61**	0.04	0.009	0.374	6.29*	235.45**
Checks	5	34.911	927.92**	82.62**	0.392**	71.73**	0.27**	0.03**	1.116**	1.972	35.54
Varieties	287	69.55**	88.62**	24.237*	0.06**	39.01**	0.03	0.009	0.314	6.19*	232.22**
C vs V	1	1.784	3,590.72**	0.654	0.075	344.84**	0.032	0.011	13.869**	57.32**	2,162.11**
Varieties+Checks vs Varieties	288	62.511*	97.06**	22.37*	0.054**	37.52**	0.029	0.006	0.351	4.62	108.693
Error323	30.136	30.285	12.233	0.024	16.846	0.022	0.006	0.217	3.186	66.332	

Source of variation	Degree of freedom	Peduncle length	Green fodder yield/plant	Leaf dry weight/ plant	Stem dry weight/ plant	Dry matter yield/plant	Leaf: stem ratio	Days to maturity	Seed yield/ plant	1000-seed weight
Block (ignoring treatments	5	97.49**	7,503.87**	203.14**	22.666	347.27**	0.489**	160.77**	274.45**	384.01**
Treatments (eliminating blocks)	293	15.62*	676.905	2.164	14.084	17.323	0.013	3.748	29.051	74.796
Blocks (eliminating treatments)	5	12.15	2,193.20	15.049	25.084	64.829	0.016	12.72**	25.553	121.25*
Treatment (ignoring blocks)	293	17.08*	767.531	5.374	14.043	22.142	0.021	6.27*	33.298	79.28*
Checks	5	95.3**	7,413.06**	6.06	23.029	27.956	0.016	1.783	208.87**	51.983
Varieties	287	15.36*	645.209	5.38	13.93	22.114	0.021	6.37*	30.176	79.94*
C vs V	1	119.62**	2,646.38	0.348	1.352	1.318	0.001	0.395	51.611	25.88
Varieties+Checks vs Varieties	288	14.24*	559.958	2.097	13.929	17.138	0.013	3.782	25.929	75.192
Error	25	7.798	1,047.20	6.162	17.756	30.918	0.02	2.89	19.524	44.903

***Significant at 0.1% probability level, **Significant at 1% probability level, *Significant at 5% probability level.

TABLE 4

Genetic variability parameters for forage yield and its contributing traits in oat (Avena sativa Sp.)

S. No.	Character	Maximum	Minimum	Grand mean	S.D.	S.E.	CV (%)
1.	DF50%T	103.00	66.00	81.29	8.06	0.47	10.16
2.	PH	147.03	86.74	115.34	9.72	0.57	4.73
3.	FLL	43.48	13.64	27.06	4.85	0.28	12.93
4.	FLW	2.52	0.74	1.70	0.24	0.01	9.09
5.	LL	59.32	26.48	43.93	6.3	0.37	9.28
6.	LW	2.98	1.34	1.97	0.18	0.01	7.52
7.	CD	0.81	0.33	0.58	0.08	0.01	13.05
8.	NN/P	6.60	3.20	4.77	0.58	0.03	9.66
9.	NT/P	16.00	2.60	7.70	2.23	0.13	23.55
10.	NL	78.17	9.80	38.63	15.97	0.93	21.5
11.	PL	46.94	22.48	30.76	3.88	0.23	9.03
12.	GFY	229.00	32.20	92.79	24.8	1.45	34.57
13.	LDW	16.00	2.00	5.56	1.62	0.09	44.58
14.	SDW	30.40	7.60	18.47	3.96	0.23	22.8
15.	DMY	41.60	10.40	24.01	4.21	0.25	23.14
16.	L:S	1.03	0.07	0.33	0.13	0.01	41.83
17.	DTM	102.00	87.00	92.19	2.1	0.12	1.84
18.	SY	32.00	2.4	18.21	5.12	0.3	24.11
19.	1000 SW	70.00	11	37.80	9.14	0.53	17.77

DT 50% F = Days to 50% flowering; LL (cm) = Leaf length; NT/P = No. of tillers per plant; DMY (g) = Dry matter yield per plant
PH (cm) = Plant height; LW (cm) = Leaf width; NL/P = No. of leaves per plant; LDW (g) = Leaf dry weight per plant
FL (cm) = Flag leaf length; CD (cm) = Culm diameter; PL (cm) = Peduncle length; SDW (g)= Stem dry weight per plant
FW (cm) = Flag leaf width; NN/P = No. of nodes on the main culm; GFY (g) = Green fodder yield; L:S = leaf: stem ratio

DTM = Days to maturity
SY (g) = Seed yield per plant
1000 SW (g) = 1000 seed weight

TABLE 5

Genetic variability parameters for forage yield and its contributing traits in oat (Avena sativa Sp.)

S.	Character	GCV (%)	PCV (%)	H2 (bs) %	GA	GA (as % of mean)	Skewness	Kurtosis
1	DF50%F	7.72	10.26	56.67	9.75	11.99	1.22 **	4.0 **
2	PH	6.62	8.16	65.82	12.78	11.08	0.1	3.7 *
3	FLL	12.8	18.19	49.53	5.03	18.59	0.08	3.6 *
4	FLW	10.9	14.21	58.87	0.29	17.25	0.17	4.1 **
5	LL	10.72	14.22	56.81	7.32	16.66	-0.09	2.8
6	LW	4.88	8.96	29.68	0.11	5.48	0.28	5.5 **
7	CD	9.62	16.24	35.06	0.07	11.75	0.06	2.8
8	NN/P	6.53	11.76	30.84	0.36	7.48	0.41 **	3.6
9	NT/P	22.52	32.32	48.56	2.49	32.38	0.74 **	3.6
10	NL	33.34	39.44	71.43	22.46	58.13	0.8 **	2.6
11	PL	8.94	12.74	49.21	3.98	12.93	0.53 **	3.9 *
12	GFY	21.60	27.38	62.30	32.44	34.96	0.33 *	3.8 *
13	LDW	15.88	41.72	14.50	69.28	12.46	1.62 **	9.7 **
14	SDW	10.6	20.21	27.49	2.11	11.42	-0.14	2.6
15	DMY	12.36	19.58	39.85	3.86	16.08	-0.04	3.3
16	L:S	11.42	43.42	6.92	0.02	6.2	1.08 **	4.9 **
17	DTM	2.02	2.74	54.65	2.85	3.09	1.38 **	7.2 **
18	SY	17.92	30.16	35.3	4	21.97	-0.21	3.6
19	1000 SW	15.66	23.65	43.83	8.08	21.39	0.35 *	3.2

DT 50% F = Days to 50% flowering; LL (cm) = Leaf length; NT/P = No. of tillers per plant; DMY (g) = Dry matter yield per plant

PH (cm) = Plant height; LW (cm) = Leaf width; NL/P = No. of leaves per plant; LDW (g) = Leaf dry weight per plant
FL (cm) = Flag leaf length; CD (cm) = Culm diameter; PL (cm) = Peduncle length; SDW (g)= Stem dry weight per plant
FW (cm) = Flag leaf width; NN/P = No. of nodes on the main culm; GFY (g) = Green fodder yield; L:S = leaf: stem ratio

DTM = Days to maturity
SY (g) = Seed yield per plant
1000 SW (g) = 1000 seed weight

TABLE 6
Correlation analysis for green forage yield and its contributing traits in oat (Avena sativa Sp.)

	PH	FL	FW	LL	LW	CD	NN	NT	NL	PL	LDW	SDW	DMW	L:S	DTM	SY	1000SW	GFY
DT50% F	-0.02	0.08	0.06	0.01	0.05	0.15	0.12	0.02	-0.13	-0.16	0.08	0.033	0.066	0.029	0.192	-0.093	0.17	0.06
PH		0.24	0.11	0.40	0.01	0.04	0.28	-0.09	-0.12	0.37	-0.05	0.024	-0.004	-0.009	-0.130	0.100	-0.04	0.27
FL			0.24	0.54	0.10	0.20	-0.11	-0.03	-0.20	0.17	0.01	0.006	0.012	0.016	-0.002	0.152	0.28	0.23
FW				0.20	0.49	0.20	0.16	0.06	-0.04	0.16	0.04	0.044	0.053	0.025	0.117	0.034	0.04	0.24
LL					0.13	0.22	0.04	-0.16	-0.20	0.31	0.08	0.027	0.063	0.075	-0.026	0.035	0.12	0.18
LW						0.31	-0.06	0.04	0.15	0.22	0.01	0.032	0.03	0.019	0.101	-0.09	0.08	0.004
CD							0.05	-0.01	-0.18	0.17	0.12	-0.002	0.058	0.126	0.242	-0.04	0.09	0.01
NN/P								-0.12	-0.10	0.03	0.09	-0.042	0.014	0.108	0.051	-0.11	-0.19	0.07
NT/P									0.29	-0.03	-0.24	0.004	-0.114	-0.223	0.258	0.151	0.10	0.04
NL										0.137	-0.28	-0.103	-0.223	-0.166	-0.090	0.029	-0.17	-0.107
PL											-0.21	-0.131	-0.206	-0.076	-0.189	0.113	-0.10	0.085
LDW												0.162	0.622	0.757	0.311	-0.349	0.022	0.24
SDW													0.873	-0.403	0.004	-0.009	0.135	0.072
DMY														0.054	0.156	-0.178	0.119	0.177
L:S															0.276	-0.279	-0.06	0.083
DTM																-0.094	0.066	0.097
SY																	0.210	0.027
1000 SW																		0.08

DT 50% F = Days to 50% flowering	LL (cm) = Leaf length	NT/P = No. of tillers per plant	DMY (g) = Dry matter yield per plant
PH (cm) = Plant height	LW (cm) = Leaf width	NL/P = No. of leaves per plant	LDW (g) = Leaf dry weight per plant
FL (cm) = Flag leaf length	CD (cm) = Culm diameter	PL (cm) = Peduncle length	SDW (g)= Stem dry weight per plant
FW (cm) = Flag leaf width	NN/P = No. of nodes on the main culm	GFY (g) = Green fodder yield	L:S = leaf: stem ratio

DTM = Days to maturity
SY (g) = Seed yield per plant
1000 SW (g) = 1000 seed weight

(mesokurtic). Kurtosis (? < 3) indicates the flatness of the curve i.e., platykurtic and if it is (? > 3) then it indicates the peak ness of a curve i.e., leptokurtic (Misra *et al.* 2008). Positive skewness i.e., longer tailed to the right shows dominant and complementary gene action where negative skewness i.e., longer tailed to the left is associated with dominant and duplicate gene action (Pooni *et al.* 1977). Leptokurtic (positive kurtosis) indicates that traits are governed by fever number of genes and platykurtic (negative kurtosis) shows that traits are governed by large number of genes (Kapur *et al.* 1981).

In the present study most of the trait showed almost normal distribution (i.e., skewness estimated not significantly different from -0.5 to 0.5 and kurtosis is 3 respectively) (Table- 5). On the other hand, most of the traits had distribution pattern showing deviation from normality *i.e.,* showed significant skewness trait like days to 50% flowering, number of tillers per plant, number of leaves of per plant, leaf dry weight per plant, leaf: stem ratio and days to maturity.

Similarly, most of the trait showed leptokurtic distribution pattern (*i.e.*, Kurtosis estimates significantly more than 3.0) and Leaf length, culm diameter, number of leaves per plant, stem dry weight per plant, dry matter weight and 1000 seed weight exhibited negative kurtosis (platykurtic). Kar *et al.* (2019) observed leptokurtic for seed yield per plant in sesame.

CORRELATION AND PATH ANALYSIS

Relationship between various morphological traits and green fodder yield was also worked out and presented in (Table 6). It is clear from the table that high positive correlation for green fodder yield was shown by leaf dry weight per plant, dry matter yield per plant, stem dry weight per plant and leaf width.

Correlation coefficients were not enough to determine traits as selection criteria in our study. In agriculture, path analyses have been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield (Dewey & Lu, 1959; Milligan *et al.* 1990). Path analysis was conducted to determine direct and indirect effect of traits on oat yield, and the results from path analysis are given in (Table 7). dry matter weight was followed by plant height, flag leaf width, flag leaf length, number of tillers per plant, peduncle length, days to maturity, seed yield per plant, number of leaves per plant, 1000 seed weight and days to 50% flowering showed significant positive correlation as well as positive direct effect on dependent character green fodder yield.

TABLE 7

Path matrix for green forage yield in oats (Avena sativa L.)

	DT 50% F	PH	FL	FW	LL	LW	CD	NN	NT	NL	PL	LDW	SDW	DMW	L:S	DTM	SY	1000	r^2 with SW
DT 50% F	0.025	-0.004	0.010	0.013	0.000	-0.005	-0.010	-0.005	0.001	-0.005	-0.010	-0.032	-0.080	0.169	-0.019	0.009	-0.004	0.005	0.06
PH	0.000	0.271	0.030	0.026	-0.012	-0.002	-0.003	-0.012	-0.006	-0.005	0.023	0.020	-0.057	-0.011	0.006	-0.006	0.004	-0.001	0.27
FL	0.002	0.065	0.125	0.057	-0.016	-0.011	-0.013	0.005	-0.002	-0.008	0.011	-0.005	-0.014	0.031	-0.011	0.000	0.007	0.008	0.23
FW	0.001	0.029	0.030	0.240	-0.006	-0.057	-0.014	-0.007	0.004	-0.002	0.010	-0.014	-0.105	0.135	-0.017	0.006	0.002	0.001	0.24
LL	0.000	0.108	0.067	0.048	-0.030	-0.015	-0.015	-0.002	-0.011	-0.008	0.019	-0.034	-0.064	0.162	-0.050	-0.001	0.002	0.003	0.18
LW	0.001	0.004	0.012	0.118	-0.004	-0.117	-0.022	0.003	0.002	0.006	0.014	-0.003	-0.076	0.076	-0.013	0.005	-0.004	0.002	0.004
CD	0.004	0.011	0.024	0.048	-0.007	-0.037	-0.069	-0.002	-0.001	-0.007	0.010	-0.048	0.004	0.150	-0.085	0.012	-0.002	0.003	0.01
NN/P	0.003	0.075	-0.013	0.039	-0.001	0.007	-0.004	-0.044	-0.008	-0.004	0.002	-0.037	0.099	0.035	-0.073	0.002	-0.005	-0.005	0.07
NT/P	0.001	-0.024	-0.003	0.015	0.005	-0.004	0.001	0.005	0.068	0.012	-0.002	0.097	-0.009	-0.292	0.150	0.012	0.007	0.003	0.04
NL	-0.003	-0.032	-0.025	-0.009	0.006	-0.018	0.013	0.004	0.020	0.040	0.009	0.114	0.244	-0.571	0.112	-0.004	0.001	-0.005	-0.107
PL	-0.004	0.100	0.021	0.039	-0.009	-0.026	-0.011	-0.001	-0.002	0.005	0.062	0.083	0.312	-0.528	0.051	-0.009	0.005	-0.003	0.085
LDW	0.002	-0.014	0.002	0.008	-0.003	-0.001	-0.008	-0.004	-0.016	-0.011	-0.013	-0.400	-0.385	1.592	-0.509	0.015	-0.016	0.001	0.24
SDW	0.001	0.006	0.001	0.011	-0.001	-0.004	0.000	0.002	0.000	-0.004	-0.008	-0.065	-2.378	2.236	0.271	0.000	0.000	0.004	0.072
DMW	0.002	-0.001	0.001	0.013	-0.002	-0.003	-0.004	-0.001	-0.008	-0.009	-0.013	-0.249	-2.076	2.560	-0.036	0.007	-0.008	0.003	0.177
L:S	0.001	-0.002	0.002	0.006	-0.002	-0.002	-0.009	-0.005	-0.015	-0.007	-0.005	-0.303	0.959	0.138	-0.672	0.013	-0.013	-0.002	0.083
DTM	0.005	-0.035	0.000	0.028	0.001	-0.012	-0.017	-0.002	0.017	-0.004	-0.012	-0.124	-0.009	0.401	-0.186	0.047	-0.004	0.002	0.097
SY	-0.002	0.027	0.019	0.008	-0.001	0.010	0.003	0.005	0.010	0.001	0.007	0.140	0.022	-0.456	0.187	-0.004	0.045	0.006	0.027
1000 SW	0.004	-0.011	0.035	0.009	-0.004	-0.009	-0.006	0.008	0.007	-0.007	-0.006	-0.009	-0.321	0.306	0.043	0.003	0.009	0.029	0.08

DT 50% F = Days to 50% flowering
PH (cm) = Plant height
FL (cm) = Flag leaf length
FW (cm) = Flag leaf width
LL (cm) = Leaf length
LW (cm) = Leaf width
CD (cm) = Culm diameter
NN/P = No. of nodes on the main culm
NT/P = No. of tillers per plant
NL/P = No. of leaves per plant
PL (cm) = Peduncle length
GFY (g) = Green fodder yield
DMY (g) = Dry matter yield per plant
LDW (g) = Leaf dry weight per plant
SDW (g)= Stem dry weight per plant
L:S = leaf: stem ratio
DTM = Days to maturity
SY (g) = Seed yield per plant
1000 SW (g) = 1000 seed weight

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