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Research Article

Frequency distribution and genetic variability for forage yield attributing traits in oats (*Avena sativa* L.)

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Abstract
An experiment was conducted with 125 germplasm accessions and five check varieties of Oat (*Avena sativa* L.) in augmented design during *rabi,* 2019-20. 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 observed for leaf:stem ratio and seed yield per plant. High heritability and high genetic advance as per cent of mean were observed for 1000 seed weight and leaf:stem ratio. High heritability combined with high genetic advance is the indication of additive gene action and selection based on this would be more effective. The skewness value for most of the traits studied in Oats ranged from -0.5 to 0.5 which indicate that these traits are normally distributed except for days to 50% flowering, flag leaf length, the number of tillers per plant, leaf dry weight per plant and leaf: stem ratio. Plant height, flag leaf width, culm diameter, dry matter yield per plant, stem dry weight per plant and seed yield per plant exhibited negative kurtosis (platykurtic).

Keywords: Variability, Skewness, Kurtosis, Forage yield and Oat

INTRODUCTION

Oat (*Avena sativa* L.) is dual purpose self pollinated hexapliod crop (2n=6x=42) with basic chromosome number (x=7) having genomic constitution of AACCDD (Rines *et al*., 2006). *A. sativa, A. byzantine* and *A. nuda* are the most commonly cultivated species from the family Poaceae. In the world, Oat ranks sixth in cereal production next to wheat, rice, maize, barley and sorghum (Oliver *et al*., 2011). It has quick regeneration ability and growth habits after cutting. Cultivation of Oat is used more for forage purposes than human consumption. It can be considered as one of the best dual purpose cereal crops that work well for the platter of cattle and humans as well. It contains a high amount of antioxidants, α- tocopherol and α-tocotrienol, as well as total dietary fiber including the soluble fiber β-glucan (Oliver *et al*., 2011).

Green fodder production is important for animals to provide balanced nutrition (Anonymous, 2002). The average yield of Oat for green fodder varies from 45 to 55 tons per hectare. Sandy loam soil is known as the best for Oat although it can be grown on various types of soils. Mostly fertile and well drained soil is suitable for Oat. The addition of lime brings the soil pH up to the range of 5.3-5.7 which can provide a high yield of Oat. It is a *rabi* crop that is usually grown from the month of October to the end of December. Early sowing provides good cutting and high production.

In India, Oat occupies a 5,00,000 ha area for its cultivation. It is cultivated maximum in Uttar Pradesh (34%), followed by Punjab (20%), Bihar (16%), Haryana

(9%) and Madhya Pradesh (6%). The rest of the area is shared by other states *viz*., Orissa, Gujarat, Uttaranchal, Maharashtra *etc*. (Anonymous, 2012). It contains protein (8-10%), dry matter (18-23%) and *in vitro* dry matter digestibility (IVDMD (60-70%) (Phogat *et al.,*2003). It is a good source for making silage and hay. There is the requirement of 761.5 MT of green fodder in the country and inspite of that India is facing a shortage of 24.7 per cent of green fodder (Solanki, 2003). Therefore, Oat is an important green forage crop that can decrease the shortage of green fodder in the country.

MATERIALS AND METHODS

The field experiment for 125 germplasm accessions and five check varieties (JHO-851, RO-19, JHO-822, UPO-212, JO-1) **(Table 1)** was conducted in the Department of Genetics and Plant Breeding, Research Cum Farm Instructional, Indira Gandhi Krishi Vishwavidyalaya, Raipur Chhattisgarh during *rabi* 2019-20. The experiment was conducted in augmented design with five blocks. Observations were recorded on five randomly selected plants in each entry in five blocks for screening of germplasm line of oats for all qualitative characters according to a descriptor of Indian grassland and Fodder Research Institute, Jhansi, India. (Roy *et al.,* 2017). Data was recorded for 19 quantitative traits *viz.,*days to 50% flowering, plant height (cm), the number of leaves per plant, flag leaf length (cm), flag leaf width (cm), leaf length (cm), leaf width (cm), culm diameter (cm), the number of nodes on the main culm, the 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 per plant (g) and 1000 seed weight (g). Variability of Oat for forage yield and its attributing traits was estimated by calculating GCV, PCV, heritability, genetic advance, skewness and kurtosis.

RESULTS AND DISCUSSION

Analysis of variance revealed that most of the raits studied were found significant at 1% and 5% levels of significance **(Table 2).** Days to 50% flowering, leaf: stem ratio and 1000 seed weight were found highly significant at 1% level of significance and traits *viz*., plant height, the number of leaves per plant, flag leaf width, leaf length, the number of tillers per plant, green fodder yield per plant, stem dry weight per plant and seed yield per plant were significant at 5% level of significance.

The genetic variability parameters estimated for different characters are presented in **Table 3**. GCV, PCV, heritability, genetic advance, skewness and kurtosis are the important parameters to estimate genetic variability. Genotypic coefficient of variation and phenotypic coefficient of variation is important and simple measures used for the estimation of variability. Values of these

Table 1. Experimental materials of Oat germplasm used to assess the variability parameters

S.No.	Genotype	S.No.	Genotype	S.No.	Genotype	S.No.	Genotype	S.No.	Genotype	S.No.	Genotype	S.No.	Genotype
1.	EC/209494	20.	EC/030245	39.	EC/0292312	58.	EC/0108486	77.	GP-1	96.	GP-28	115.	GP-17
2.	EC/0076710	21.	EC/022079	40.	EC/292362	59.	EC/096592	78.	GP-2	97.	GP-40	116.	GP-11
3.	EC/0101747	22.	EC/022080	41.	EC/292371	60.	EC/096541	79.	GP-3	98.	GP-15	117.	GP-19
4.	EC/009884	23.	EC/097519	42.	EC/292275	61.	EC/209211	80.	GP-4	99.	GP-16	118.	GP-35
5.	EC/009888	24.	EC/097241	43.	EC/0292369	62.	EC/0107539	81.	GP-5	100.	GP-38	119.	GP-36
6.	EC/060978	25.	EC/097537	44.	EC/0292340	63.	EC/0107524	82.	GP-6	101.	GP-18	120.	UPO-12-1
7.	EC/009885	26.	EC/0102326	45.	EC/0292267	64.	EC/0107528	83.	GP-7	102.	GP-46	121.	1760
8.	EC/008539	27.	EC/060977	46.	EC/036779	65.	EC/029056	84.	GP-8	103.	GP-32	122.	405
9.	EC/097525	28.	EC/060975	47.	EC/036821	66.	EC/035103	85.	GP-10	104.	GP-30	123.	RO-11
10.	EC/097536	29.	EC/0102324	48.	EC/0035766	67.	EC/035051	86.	GP-33	105.	GP-13	124.	OL-1804
11.	EC/097541	30.	EC/097533	49.	EC/014016	68.	EC/034585	87.	GP-34	106.	GP-39	125.	OL-10
12.	EC/097531	31.	EC/097532	50.	EC/035765	69.	EC/034588	88.	GP-27	107.	GP-31	**Checks**	
13.	EC/097538	32.	EC/097530	51.	EC/035768	70.	EC/034587	89.	GP-25	108.	GP-22	126.	JHO-851
14.	EC/097248	33.	EC/097520	52.	EC/0131307	71.	EC/246147	90.	GP-48	109.	GP-43	127.	RO-19
15.	EC/097528	34.	EC/097539	53.	EC/066172	72.	EC/246146	91.	GP-44	110.	GP-50	128.	JHO-822
16.	EC/009890	35.	EC/097535	54.	EC/209196	73.	IC/282934	92.	GP-20	111.	GP-42	129.	UPO-212
17.	EC/009883	36.	EC/097240	55.	EC/0107017	74.	IC/014555	93.	GP-21	112.	GP-49	130.	JO-1
18.	EC/009889	37.	EC/292328	56.	EC/039899	75.	IC/0625278	94.	GP-12	113.	GP-41		
19.	EC/097522	38.	EC/292363	57.	EC/209215	76.	EC/096591	95.	GP-26	114.	GP-37		

Source of material: National Bureau of Plant Genetic Resources

Table 2. Analysis of variance for green fodder yield and its attributing traits in Oat

		Mean sum of square (MSS)									
Source of variation	**Degree of freedom**	**Days to 50% flowering**	**Plant height**	**Number of leaves/ plant**	**Flag leaf length**	**Flag leaf width**	**Leaf length**	**Leaf width**	**Culm diameter**	**Number of nodes/ plant**	**Number of tillers/ plant**
Block	4	30.657	1644.311	521.406	48.747	0.082	174.731	0.198	0.612	2.342	18.257
Genotypes	129	28.022**	80.519*	48.155*	9.164	0.031*	28.709*	0.024	0.207	0.298	2.232*
Error	16	7.415	63.794	55.797	7.595	0.029	13.973	0.022	0.291	0.238	2.121

		Mean sum of square (MSS)								
Source of variation	**Degree of freedom**	**Peduncle length**	**Green fodder yield/ plant**	**Dry matter yield/ plant**	**Leaf dry weight/ plant**	**Stem dry weight/ plant**	**Leaf: stem ratio**	**Days to maturity**	**Seed yield/ plant**	**1000 seed weight**
Block	4	53.706	24165.020	346.118	51.097	141.464	0.043	53.727	201.953	309.327
Genotypes	129	6.077	479.290*	31.453	3.438	18.774*	0.015**	7.708	34.739*	51.047**
Error	16	5.369	741.201	35.689	3.529	19.034	0.005	3.861	14.075	4.610

*Significant at 5 % level **Significant at 1 % level

Table 3. Variability parameters for Oat genetic accessions

S.No.	**Trait**	**PCV (%)**	**GCV (%)**	**H^2 (bs) %**	**GA**	**GA (as % of mean)**	**Kurtosis**	**Skewness**
1	Days to 50% flowering	4.90	3.20	42.57	3.15	4.30	4.9270 ***	1.5565 ***
2	Plant height	10.13	6.90	46.38	10.42	9.68	-0.0981	0.3195
3	Number of leaves per plant	27.17	3.82	1.97	0.31	1.11	0.2220	0.1182
4	Flag leaf length	10.21	4.61	20.42	1.30	4.30	0.8760 *	-0.5091 *
5	Flag leaf width	8.87	1.49	2.83	0.01	0.52	-0.0705	0.2601
6	Leaf length	11.78	8.66	54.13	6.15	13.13	0.7641	-0.0067
7	Leaf width	8.95	3.87	18.68	0.06	3.45	0.1256	0.3338
8	Culm diameter	7.72	-4.21	-29.78	-0.29	-4.73	-0.1227	0.1846
9	Number of nodes on the main culm	11.64	6.05	27.01	0.32	6.48	0.9199 *	-0.2796
10	Number of tillers per plant	25.77	7.98	9.59	0.30	5.09	1.2819 **	0.5405 *
11	Peduncle length	7.82	3.72	22.64	1.23	3.65	0.5177	0.0913
12	Green fodder yield per plant	32.54	16.05	24.32	15.68	16.30	0.4788	-0.4585 *
13	Dry matter yield per plant	22.66	1.35	00.35	0.04	0.17	-0.3133	0.0022
14	Leaf dry weight per plant	25.65	11.33	19.51	0.84	10.31	1.2165 **	0.7823 ***
15	Stem dry weight per plant	24.43	4.76	3.80	0.35	1.91	-0.2070	0.0055
16	Leaf: stem ratio	26.82	21.96	67.04	0.17	37.04	3.3157 ***	1.1931 ***
17	Days to maturity	2.44	1.64	45.42	2.49	2.28	3.8678 ***	0.3631
18	Seed yield per plant	28.60	20.78	52.78	5.94	31.10	-0.3149	0.1239
19	1000 Seed weight	17.37	16.37	88.81	11.74	31.77	0.7646	-0.1270

* Significant at 5 % level ** Significant at 1 % level ***Significant at 0.1% level

types of measures provide information about the amount of variation present in the genotypes for given traits. To measure the magnitude of variation genotypic and phenotypic coefficients of variation are classified into 3 categories *i.e*., high (>20%), moderate (10-20%) and low (<10%) as proposed by Krishna *et al.* (2014).

The highest GCV (21.96%) was observed for leaf:stem ratio and seed yield (20.78%); moderate for 1000 seed weight (16.37%) followed by green fodder yield (16.05%) and (11.33%) for leaf dry weight and the lowest for culm diameter (-4.21 %) which was followed by dry matter yield (1.35 %), flag leaf width (1.49 %) and days to maturity (1.64 %). Similarly, the highest PCV (32.54 %) was recorded for trait green fodder yield, seed yield (28.6 %), the number of leaves per plant (27.17 %), leaf:stem ratio (26.82%), the number of tiller (25.77 %), leaf dry weight (25.65 %), stem dry weight (24.43 %), and dry matter yield (22.66%); moderate for 1000 seed weight (17.37 %), leaf length (11.78 %) and the number of node per plant (11.64 %) and the lowest value was observed for days to maturity (2.44 %), days to 50% flowering (4.9 %), culm diameter (7.72 %) and for peduncle length (7.827 %).

Values of phenotypic coefficient of variation were recorded more than genotypic coefficient of variation which indicates the influence of environment on the genotypes studied. The highest values for GCV and PCV was observed for leaf: stem ratio and seed yield indicating a sufficient amount of variation present among the genotypes. Selection of both traits will show the efficient result for the further breeding programme. A high value of GCV and PCV for seed yield was also observed by Chakraborty *et al.* (2014) and Surje and De (2014). Heritability can be expressed as phenotypic variation present in a population due to genotypic variation. It is a percentage transfer of character from one generation to another. Heritability along with genetic advances is considered as more efficient to gain the knowledge of genetic factors of any phenotype. Heritability and genetic advance are important parameters that increase the effectiveness of selection for any genotype.

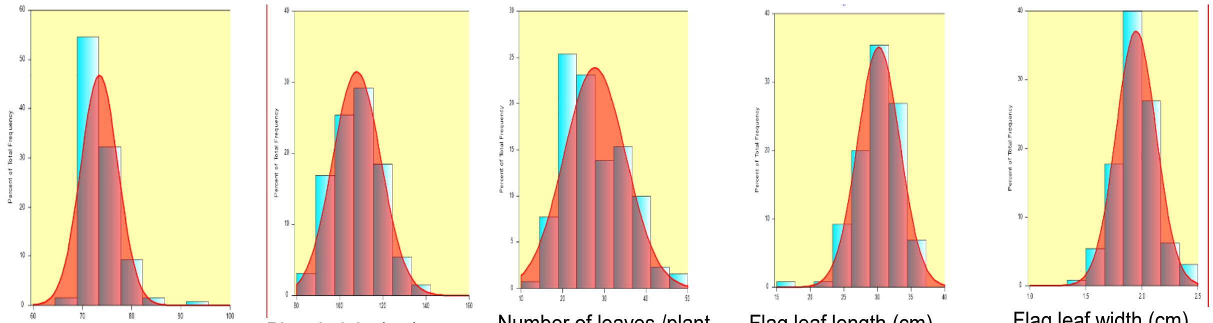
As suggested by Johnson *et al.* (1955) broad sense heritability is grouped into three classes *i.e.* high (>60%), moderate (40-60%) and low (<40%). High heritability was found for the character 1000 seed weight and leaf:stem ratio as (88.81%) and (67.04%), respectively **(Table 3).** Moderate heritability was recorded for trait leaf length (54.13%), seed yield (52.78%), plant height (46.38%), days to maturity (45.42%) and days to 50% flowering (42.57%). The lowest heritability was found for culm diameter (-29.78%) followed by dry matter yield (0.35%), and the number of leaves per plant (1.97%). Krishna *et al.* (2013) and Rawat *et al.* (2019) observed high heritability for 1000 seed weight and leaf:stem ratio. Genetic advance is classified in 3 categories *i.e.* A high (>20%), moderate (10-20%) and low (<10%) suggested by Johnson *et al.* (1955). High genetic advance was observed for leaf:stem ratio (37.04%), 1000 seed weight (31.77%) and seed yield (31.1%). The moderate genetic advance was found in green fodder yield (16.30%), leaf length (13.13%) and dry leaf weight (10.3%). The low genetic advance was observed in culm diameter (-4.73%), which was followed by flag leaf width (0.51%) and dry matter yield (0.16%). Mall *et al.* (2005), Krishna *et al.* (2013), Chakraborty *et al.* (2014), Surje and De (2014) and Rawat *et al.* (2019) observed high genetic advance for seed yield per plant. Krishna *et al.* (2013) and Rawat *et al.* (2019) also observed high genetic advance for 1000 seed weight and leaf:stem ratio.

High heritability combined with high genetic advance is an indication of additive gene action and selection based on this would be more effective. High heritability coupled with high genetic advance as per cent of mean was found for 1000 seed weight and leaf:stem ratio. These findings is relevant to the results of Krishna *et al.* (2013) and Rawat *et al.* (2019) as they observed high heritability coupled with the high genetic advance in 1000 seed weight and leaf:stem ratio, respectively.

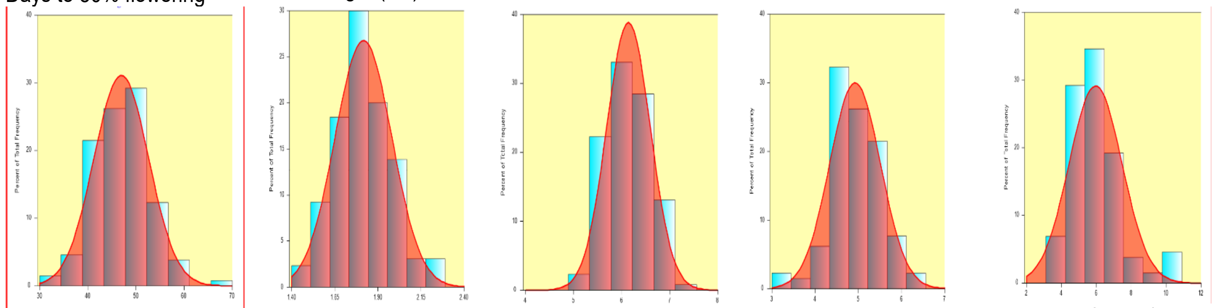
Skewness and kurtosis indicate relative mean performance and nature of the distribution of traits. Skewness represents the asymmetry of data distributed in a normal distribution curve. It is a distortion of symmetry. If value ranges from -0.5 to 0.5 then the data is normally distributed *i.e.* symmetrical. Kurtosis indicates the peakness or flatness of a tail of a curve. If the value is near 0, then the data is normally distributed. Kurtosis of < 0 indicates the flatness of the curve *i.e.* platykurtic and if it is > 0 then it indicates the peakness of a curve *i.e.* leptokurtic (Kanavi *et al.,* 2020).

Skewness and kurtosis indicate the nature of gene action and the number of genes controlling any trait. Positive skewness shows dominant and complementary gene action and negative skewness is associated with dominant and duplicate gene action (Pooni *et al.,* 1977). leptokurtic (positive kurtosis) indicates that traits are governed by a fever number of genes and platykurtic (negative kurtosis) shows that traits are governed by a large number of genes (Kapur, 1981). Skewness and kurtosis of different traits are represented in **Fig.1.**

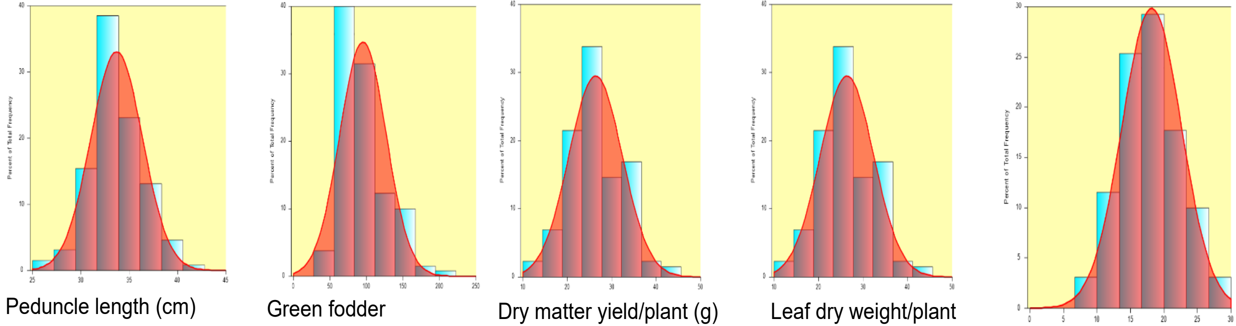
Most of the traits studied had skewness values ranged from -0.5 to 0.5 and were normally distributed except days to 50% flowering (1.5565), leaf:stem ratio (1.1931), leaf dry weight per plant (0.7823) and the number of tillers per plant (0.5405), which was showed positive skewness indicating a dominant and complementary gene action. While flag leaf length (-0.5091) showed negative skewness and exhibit dominant and duplicate gene action.



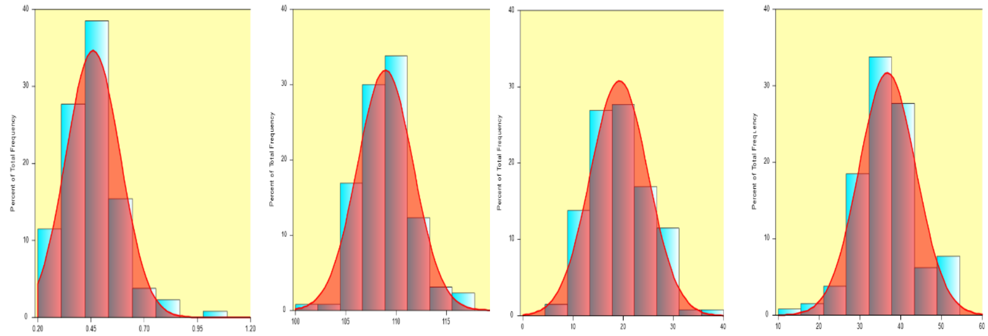
Days to 50% flowering Plant height (cm) Number of leaves /plant Flag leaf length (cm) Flag leaf width (cm)



Leaf length (cm) Leaf width (cm) Culm diameter (cm) Number of nodes Number of tillers/plant



Peduncle length (cm) Green fodder yield/plant (g) Dry matter yield/plant (g) Leaf dry weight/plant (g)on the main culm Stem dry weight/plant (g)



Leaf: stem ratio Days to maturity Seed yield/plant (g) 1000 Seed weight (g)

Fig 1. Histogram showing skewness and kurtosis of different quantitative traits in Oat

Plant height (-0.0981), flag leaf width (-0.0705), culm diameter (-0.1227), dry matter yield per plant (-0.3133), stem dry weight per plant (-0.2070) and seed yield per plant (-0.3149) exhibited negative kurtosis (Platykurtic) indicating traits are controlled by a large number of genes and rest of the traits showed positive kurtosis (Leptokurtic) are governed by few genes. Savitha and Kumari (2015) observed platykurtic and left skewed distribution for days

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to 50 per cent flowering, plant height, the number of productive tillers per plant, panicle length, hundred grain weight and single plant yield in rice. Kanavi *et al.* (2020) reported all the quantitative traits studied in germplasm accessions exhibited skewness values between -0.5 and 0.5 except for the traits leaf water potential (0.69) and seed yield per plant (0.66) indicating normal distribution for these traits in the population in green gram. Neelima *et al.* (2020) found days to silking, tassel length, the number of tassel branches, leaf length, leaf breadth, cob length, the number of kernels per row, cob weight, 100 kernel weight and single plant yield had positive skewness and platykurtic nature in maize.

The highest values for GCV and PCV was observed for leaf:stem ratio and seed yield indicating a sufficient amount of variation present among the genotypes. High heritability coupled with high genetic advance as per cent of mean was observed for 1000 seed weight and leaf: stem ratio. Most of the traits studied in Oats had skewness values from -0.5 to 0.5, indicated that these traits are normally distributed except for days to 50% flowering, flag leaf length, number of tillers per plant, leaf dry weight per plant and leaf: stem ratio. Plant height, flag leaf width, culm diameter, dry matter yield per plant, stem dry weight per plant and seed yield per plant exhibited negative kurtosis (platykurtic).

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