Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 786-790
Received: 24-05-2018
Accepted: 29-06-2018

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Evaluation of morphological and quality parameters in forage oat

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Abstract
The data on morphological, seed and quality characters was collected to evaluate the performance of ninety two genotypes of oat under single cut and multi-cut systems. In single cut oat the green fodder yield were considered, while in multi-cut system, 1st cut with eleven and 2nd cut with twenty traits were evaluated. The magnitude of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) in 1st cut found high for green fodder yield per meter row length (Kg) and dry matter yield per meter row length (Kg) and in 2nd cut for flag leaf length (cm), inter-node length (cm), peduncle length (cm), axis length(cm), leaf width (cm), green fodder yield per meter row length (Kg) and dry matter yield per meter row length (Kg). High heritability coupled with high expected genetic advance as percent of mean was high for the traits including plant height (cm), green fodder yield (Kg) and dry matter yield (Kg) in1st cut while the traits, like flag leaf length (cm), inter-node length (cm), peduncle length (cm), axis length (cm), seed index (cm), leaf length (cm), green fodder yield (Kg), dry matter yield (Kg) and crude protein (%) in 2nd cut.
The superior genotypes identified for green fodder yield on the basis of their comparison with single cut oat were HFO-114, HFO-414, HJ 8, HFO-60, HFO-920, HFO-902, HFO-896, HFO-78, HFO-863 and HFO-845 on the basis of higher mean values.

Keywords: single cut, multi-cut, heritability, crude protein, fixable gene effect, genetic advance

Introduction
Oat (*Avena sativa* L.) in India is grown mainly of the purpose livestock fodder. Green fodder can be harvested either as single cut or as multi-cut depending upon the green fodder requirement. Earlier, the oat crop has not been preferred because it is cultivated in cropping areas not optimal for wheat, barley or maize, but now the interest in oats has increased, due to its dietary benefits and therapeutic potential for human health. The uniqueness and advantages of oats over other popular cereals, because of its highly valuable nutritional characteristics, have been well studied and reported, opening new market "niches" for oats. Even though, the status of the oat crop is still fragile, including reasons that the area under oat crop is very less compared with other cereals and therefore commercial efforts in oat breeding are less. Oat groat yield is lower than other cereals such as wheat and the nutritious uniqueness has not been reflected in agreeable market prices. The absence of visible market competitiveness, and some of the oat biological drawbacks, including low grain yield, keeps the oat crop as a lower profitability minor crop (Gorash *et al.* 2017) [4].
The variability is pre-requisite in the breeding programme for the improvement of qualitative and quantitative traits. The germplasm is evaluated for assessing genetic variability for novel traits using morphological measurements. The methods, such as introduction, hybridization and mutation are used for creating variability in the population. Variability is the differences in individuals of a population arising either due to genetic constitution or the environment in which they are grown. The nature and magnitude of variation present in the evaluated germplasm is of immense significance for effective selection of superior genotypes from breeding the material. Hence, it is essential that the base population should possess heritability along with high genetic advance.

Methods and Material
The research data on agro-morphological and quality characters was formulated to assess the performance of ninety two genotypes of oat under single cut and multi-cut systems. In single cut oat the green fodder yield was considered, while in multi-cut system, 1st cut with eleven and 2nd cut with twenty traits were evaluated. The experiment was conducted at the Forage Research Area, Department of Genetics & Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar during *rabi* 2015-16 and Randomized block design was adopted with three replications keeping row to row distance 45 cm and plant to plant distance at 10 cm.

The observations were recorded on five competitive plants selected randomly from each genotype in each replication. The data were subjected to analysis of variance adopting standard statistical methods (Panse and Sukhatme, 1985) [7]. The genotypic and phenotypic coefficients of variation were categorized as per the method suggested by Shivasubramanian and Menon (1973) [9]. Expected genetic advance was estimated as per the formula suggested by Johnson *et al*. (1955) [5].

Results and Discussions

The single cut oat data recorded on the basis of mean green fodder yield have been presented in the (Table 1) along with the means of genotypes under multi-cut oat including 1st cut, 2nd cut and total green fodder yield in multi-cut. The Analysis of variance revealed that significant differences existed among the genotypes for all the characters studied in multi-cut oat (Table 2). The mean, range and estimates of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense and genetic advance as per cent of mean (GA) are presented in Table 3.

These genotypes taken from different eco-geographical regions had diverse genetic background. The traits like plant height (27- 68 cm), number of tillers per plant (6.6-10), green fodder yield (0.087- 0.372 Kg), dry matter yield (0.030- 0.082 Kg) and crude protein in forage (12.10-15.60 %) in 1st cut. While in 2nd cut the traits included were plant height (43-98 cm), number of days to 50% flowering (111- 134), flag leaf length (12 - 33 cm), inter-node length (8- 24 cm), number of tillers per plant (7.1-10.5), peduncle length (12-38cm), axis length (8.3- 28.7 cm), seed index (2.00- 4.60 g), leaf length (9.0 -50.0 cm), leaf width (0.6- 2.8 cm), green fodder yield (0.220- 0.860 Kg), dry matter yield (0.080- 0.190 Kg), number of leaves per plant (30 - 50) and crude protein forage (9.63-13.57 %) had wide range of variation. The seed quality traits included germination % (81.0- 92.2 %), seedling length (27.6-38.7 cm), seedling dry weight (7.0- 15.6 mg), seed vigour index I (2335.3- 3526.2), seed vigour index II (593.9-1368.2) and electrical conductivity (0.10- 0.40dS/m/seed) were analysed in both 1st cut and 2nd cut oat also had wide range of mean values.

In 1st cut of multi-cut oat, the estimates of genotypic coefficient of variation (GCV) and Phenotypic coefficient of variance (PCV) were high (›20%) for green fodder yield per meter row length (Kg) and dry matter yield per meter row length (Kg).Whereas it was moderate (10-20%) for plant height (cm) and low (<10) for number of tillers per plant and crude protein in forage. Heritability estimates were high (>60) for number of tillers per plant, green fodder yield per meter row length (Kg), dry matter yield per meter row length (Kg) and crude protein in forage (%) whereas moderate (30<60%) for plant height (cm). Expected genetic advance as percent of mean was high (›20%) for the traits, namely, plant height (cm), green fodder yield (Kg) and dry matter yield (Kg) and was medium (10- 20%) for number of tillers per plant and low (<10) for crude protein in forage (%).

In 2nd cut of multi-cut oat, the estimates of genotypic coefficient of variation (GCV) were high (›20%) for flag leaf length (cm), inter-node length (cm) and green fodder yield per meter row length (Kg) and dry matter yield per meter row length (Kg).Whereas it was moderate (10-20%) for plant height (cm), peduncle length (cm), axis length (cm), seed index (g), leaf length (cm), leaf width (cm) and dry matter yield per meter row length (Kg). Phenotypic coefficient of variance (PCV) was high (›20%) for flag leaf length (cm), internode length (cm), peduncle length (cm), axis length(cm), leaf width (cm), green fodder yield per meter row length (Kg) and dry matter yield per meter row length (Kg). Whereas it was moderate (10-20%) for plant height (cm), seed index (g), leaf length (cm), number of leaves per plant. The earlier researchers Arora (2013) [3]; Surje *et al*. (2014) [10] and Bind *et al*. (2016) [2] also found a large and exploitable variation in oat germplasm. It implies that that there is enough scope for improvement through selection for the traits investigated in the present material.

Heritability estimates were high (>60) for days to 50 % flowering, flag leaf length (cm), inter-node length (cm), numbers of tillers per plant, peduncle length (cm), axis length (cm), seed index (g), leaf length (cm), leaf width (cm), green fodder yield per meter row length (Kg) and crude protein in forage (%) whereas moderate (30<60%) for remaining characters. Expected genetic advance as percent of mean was high (›20%) for the traits, namely, flag leaf length (cm), inter-node length (cm), peduncle length (cm), axis length (cm), seed index (cm), leaf length (cm), leaf width (cm), green fodder yield (Kg) and dry matter yield (Kg).While genetic advance as percent of mean was medium (10- 20%) for plant height (cm), number of tillers per plant, number of leaves per plant and crude protein in forage (%). Low genetic advance as percent of mean (<10%) was observed for days to 50 % flowering. Traits showing high heritability coupled with high genetic advance suggests that these traits are under the control of additive (fixable) gene effects; therefore they are highly reliable for effective selection based on phenotypic performance (Bind *et al*., 2016) [2]. High variability for dry matter yield/meter row length and green fodder yield per meter row length in first and second cut of multi-cut was also reported by Arora (2013). High heritability and high genetic advance for characters like [1] tillers per plant, green fodder yield and dry matter yield also recorded by Singh and Singh (2011) [8]. Chakraborty *et al*. (2014) [3] observed high heritability coupled with high genetic advance for traits like green fodder yield and 100 seed weight. These results indicated the scope for improvement through selection in these characters.

The genotypes JO-1, JHO-99-1, DULO, UPO-212, KENT, HFO-864, HFO-879, HFO-58, HFO-878 and HFO-409 were found superior with highest green fodder yield in single cut oat, while genotypes HFO-114, HFO-58, HFO-414, HJ 8, HFO-60, HFO-920, HFO-902, ALGERIAN, HFO-896 and HFO-433 were best in multi-cut oat. Top twenty five genotypes were selected from the multi-cut oat having highest total green fodder yield and compared with their green fodder yield in single cut oat (Figure 1). The genotypes which yielded lower or similar green fodder yield in single cut oat were selected for multi-cut oat, as they performed better under multi-cut regimes and made available the green fodder for longer period which is preferred by the livestock. The genotypes HFO-114, HFO-414, HJ 8, HFO-60, HFO-920, HFO-902, HFO-896, HFO-78, HFO-863 and HFO-845 performed better and should be utilized in multi-cut oat breeding programme.

Table 1: List of 92 genotypes showing green fodder yield in single cut and multi-cut Oat

S. N.	Genotypes	Source	Gfy 1st cut	Gfy 2nd cut	Total Gfy	Single cut GFY	S. N.	Genotypes	Source	Gfy 1st cut	Gfy 2nd cut	Total Gfy	Single cut GFY
1	JO-1	JNKVV, Jabalpur	223	443	666	1.679	47	HFO-433	CCSHAU, Hisar	205	813	679	1.051
2	ALGERIAN	ALGERIA	199	660	859	1.181	48	HFO-885	CCSHAU, Hisar	222	742	675	0.959
3	HFO-267	CCSHAU, Hisar	175	524	699	0.689	49	HFO-896	CCSHAU, Hisar	171	819	674	0.797
4	OL-125	PAU, Ludhiana	267	407	674	1.155	50	HFO-839	CCSHAU, Hisar	282	739	673	0.756
5	0L-10	PAU, Ludhiana	201	353	554	0.812	51	HFO-836	CCSHAU, Hisar	273	716	670	0.665
6	PLP-1	CSKHPAU, Palampur	125	610	735	0.804	52	HFO-863	CCSHAU, Hisar	154	794	668	0.721
7	JHO-2006-4	IGFRI, Jhansi	242	412	654	1.038	53	HFO-884	CCSHAU, Hisar	262	682	667	0.707
8	SABZAR	SKAUST, Shrinagar	255	410	665	0.870	54	HFO-841	CCSHAU, Hisar	220	657	666	0.771
9	DUNAV	BULGARIA	202	512	714	0.704	55	HFO-851	CCSHAU, Hisar	173	606	665	0.580
10	JHO-851	IGFRI, Jhansi	210	408	618	1.136	56	HFO-880	CCSHAU, Hisar	179	612	662	0.605
11	UPO-94	GBPUAT, Pantnagar	195	505	700	0.822	57	HFO-893	CCSHAU, Hisar	223	716	657	0.472
12	JHO-822	IGFRI, Jhansi	224	507	731	1.035	58	HFO-852	CCSHAU, Hisar	231	453	654	0.468
13	SKO-90	SKAUST, Shrinagar	207	407	614	0.627	59	HFO-870	CCSHAU, Hisar	158	535	651	0.594
14	JHO-99-1	IGFRI, Jhansi	330	285	615	1.488	60	HFO-862	CCSHAU, Hisar	236	509	634	0.500
15	FOS-1/29	CCSHAU, Hisar	315	463	778	1.177	61	HFO-845	CCSHAU, Hisar	307	764	634	0.793
16	DULO	BULGARIA	205	463	668	1.553	62	HFO-883	CCSHAU, Hisar	252	689	620	1.241
17	UPO-212	GBPUAT, Pantnagar	372	365	737	1.446	63	HFO-831	CCSHAU, Hisar	173	775	619	1.084
18	OS-6	CCSHAU, Hisar	243	503	746	1.055	64	HFO-114	CCSHAU, Hisar	175	1032	618	1.003
19	JHO-2006-2	IGFRI, Jhansi	140	527	667	0.825	65	HFO-832	CCSHAU, Hisar	150	593	617	0.868
20	KENT	AUSTRALIA	179	393	572	1.329	66	HFO-603	CCSHAU, Hisar	174	811	615	1.257
21	HFO-505	CCSHAU, Hisar	242	477	719	1.065	67	HFO-605	CCSHAU, Hisar	200	717	614	1.048
22	HFO-975	CCSHAU, Hisar	227	424	651	0.884	68	HFO-611	CCSHAU, Hisar	217	514	612	1.145
23	HFO-69	CCSHAU, Hisar	196	562	758	1.080	69	HFO-704	CCSHAU, Hisar	222	662	609	1.099
24	HFO-876	CCSHAU, Hisar	232	448	680	0.578	70	HFO-715	CCSHAU, Hisar	204	617	606	1.217
25	HFO-305	CCSHAU, Hisar	202	417	619	1.088	71	HFO-610	CCSHAU, Hisar	247	704	603	0.729
26	HFO-504	CCSHAU, Hisar	214	300	514	0.808	72	HFO-706	CCSHAU, Hisar	250	590	601	0.692
27	HFO-864	CCSHAU, Hisar	244	523	767	1.567	73	HFO-703	CCSHAU, Hisar	163	573	593	1.126
28	HFO-865	CCSHAU, Hisar	218	577	795	1.096	74	HFO-575	CCSHAU, Hisar	238	555	590	0.646
29	HFO-877	CCSHAU, Hisar	212	485	697	0.639	75	HFO-614	CCSHAU, Hisar	225	712	575	0.755
30	HFO-879	CCSHAU, Hisar	253	537	790	1.495	76	HFO-707	CCSHAU, Hisar	213	673	573	0.855
31	HFO-502	CCSHAU, Hisar	324	389	713	1.036	77	HFO-905	CCSHAU, Hisar	175	528	572	0.924
32	HFO-58	CCSHAU, Hisar	337	690	1027	1.847	78	HFO-908	CCSHAU, Hisar	241	679	570	0.905
33	HFO-78	CCSHAU, Hisar	246	548	794	0.733	79	HFO-914	CCSHAU, Hisar	143	453	560	0.790
34	HFO-60	CCSHAU, Hisar	223	713	936	0.876	80	HFO-909	CCSHAU, Hisar	172	540	555	1.119
35	HFO-603	CCSHAU, Hisar	207	427	634	0.872	81	HFO-904	CCSHAU, Hisar	236	799	554	0.918
36	HFO-878	CCSHAU, Hisar	235	435	670	1.474	82	HFO-910	CCSHAU, Hisar	208	675	547	1.230
37	HFO-874	CCSHAU, Hisar	228	347	575	0.604	83	HFO-913	CCSHAU, Hisar	137	464	544	1.041
38	HFO-875	CCSHAU, Hisar	227	317	544	0.661	84	HFO-921	CCSHAU, Hisar	203	570	540	0.631
39	HFO-872	CCSHAU, Hisar	87	473	560	0.501	85	HFO-924	CCSHAU, Hisar	240	700	535	1.506
40	HFO-498	CCSHAU, Hisar	225	376	601	0.548	86	HFO-919	CCSHAU, Hisar	194	634	528	1.063
41	HFO-867	CCSHAU, Hisar	160	387	547	0.506	87	HFO-906	CCSHAU, Hisar	182	609	514	0.709
42	HFO-508	CCSHAU, Hisar	110	572	682	1.000	88	HFO-912	CCSHAU, Hisar	319	762	514	1.612
43	Kalojan	Bulgaria	150	470	620	0.912	89	HFO-902	CCSHAU, Hisar	214	881	509	0.740
44	HFO-409	CCSHAU, Hisar	242	450	692	1.228	90	HFO-920	CCSHAU, Hisar	219	899	464	0.946
45	HFO-414	CCSHAU, Hisar	175	828	1003	0.795	91	HFO-920 (check)	CCSHAU, Hisar	230	943	453	1.157
46	HFO-523	CCSHAU, Hisar	208	395	603	0.941	92	HJ 8 (check)	CCSHAU, Hisar	240	804	453	1.391

Table 2: Analysis of variance for green fodder yield and its component characters in multi-cut oat

Sources of variation	Cut type	d. f.	Mean squares																			
			PH	DF	FLL	IL	TPL	PL	AL	SI	LL	LW	GFY	DMY	NOL	CP	GP	SL	SDW	SV-1	SV-2	EC
Replication	Ist cut	2	337.45	—	—	—	1.404	—	—	—	—	—	4262.047	582.6	—	0.431	2835.76	1.4	42.83	3276873	2326.78	0.024
	2nd cut		167.24	3565.45	0.623	0.406	0.013	8.32	16.63	1.92	7.52	0.206	1804.34	57.89	23.83	0.751						
Genotypes	Ist cut	91	231.4**	—	—	—	1.397**	—	—	—	—	—	7213.9**	412.6**	—	1.51**	26.41**	14.03**	11.96**	176467.5**	88064.4**	0.015**
	2nd cut		371.0**	103.6**	69.7**	38.4**	1.396**	78.44**	45.75	0.772**	105.0**	0.39**	41455.0**	1903.04**	53.22**	3.40**						
Error	Ist cut	182	53.394	—	—	—	0.245	—	—	—	—	—	603.76	70.862	—	0.217	4.99	0.889	0.046	12384.97	745.44	0.001
	2nd cut		93.19	2.94	5.09	3.39	0.246	6.96	4.66	0.012	13.22	0.021	7526.6	352.82	15.26	0.167						

** Significant at 1%, * Significant at 5%

PH- Plant height(cm), DF - No. of days to 50% flowering, F LL- Flag leaf length(cm), IL- Internode length(cm), TPL-Number of tillers per plant, PL- Peduncle length(cm), AL- Axis length(cm), SI- Seed index, LL- Leaf length (cm), LW- Leaf width(cm), GFY- Green fodder yield(Kg), DMY- Dry matter yield(Kg), NOLS- Number of leaves per plant, CP2- Crude protein in forage(%), GP- Germination %, SL- Seedling length (cm), SDW- Seedling dry weight(mg), SVI- Seed vigour index-1, SVII- Seed vigour index-2, EC- Electrical conductivity (mS/cm/seed).

Table 3: Mean, range, co-efficient of variation (GCV & PCV), heritability and genetic advance as % of mean for various yield and quality traits in 92 genotypes in multi-cut Oat

Characters	Cut type	Mean	Range		Coefficient of variation (%)		Heritability % broad sense	Genetic advanceas % of mean
			Min.	Max.	Genotypic	Phenotypic		
Plant height (cm)	Ist cut	54	27	68	14.183	19.547	52.648	21.199
	2nd cut	74.28	43	98	12.96	18.35	49.84	18.84
Days to 50% flowering	Ist cut	-	-	-	-	-	-	-
	2nd cut	119.62	111	134	4.84	5.05	91.95	9.57
Flag leaf length (cm)	Ist cut	-	-	-	-	-	-	-
	2nd cut	22.29	12	33	20.83	23.16	80.89	38.59
Internode length (cm)	Ist cut	-	-	-	-	-	-	-
	2nd cut	16.54	8	24	20.69	23.49	77.53	37.52
No. of tillers /plant	Ist cut	8.34	6.6	10	7.429	9.513	60.977	11.95
	2nd cut	8.77	7.1	10.5	7.06	9.04	60.98	11.36
Peduncle length (cm)	Ist cut	-	-	-	-	-	-	-
	2nd cut	24.45	12	38	19.97	22.69	77.4	36.18
-Axis length (cm)	Ist cut	-	-	-	-	-	-	-
	2nd cut	21.28	8.3	28.7	17.39	20.14	74.61	30.95
Seed index (g)	Ist cut	-	-	-	-	-	-	-
	2nd cut	3.36	2	4.6	14.99	15.33	95.64	30.2
Leaf length(cm)	Ist cut	-	-	-	-	-	-	-
	2nd cut	30.75	9	50	14.07	15.96	77.68	25.54
Leaf width (cm)	Ist cut	-	-	-	-	-	-	-
	2nd cut	1.76	0.6	2.8	19.93	21.53	85.63	37.98
Green fodder yield (Kg)	Ist cut	0.216	0.087	0.372	21.718	24.513	78.492	39.636
	2nd cut	0.47	0.22	0.86	22.6	29.17	60.04	36.08
Dry matter yield (Kg)	Ist cut	0.051	0.03	0.082	21.098	26.871	61.65	34.126
	2nd cut	0.12	0.08	0.19	18.92	24.55	59.43	30.05
No. of leaves/plant	Ist cut	-	-	-	-	-	-	-
	2nd cut	40.56	30	50	8.77	13.03	45.32	12.16
Crude protein forage (%)	Ist cut	14	12.1	15.6	4.687	5.747	66.502	7.874
	2nd cut	11.87	9.63	13.57	8.75	9.41	86.59	16.78
Germination%	both cut	86.9	81	92.2	3.1	4	58.9	4.9
Seedling length (cm)	both cut	31.9	27.6	38.7	6.6	7.2	83.1	12.3
Seedling dry weight	both cut	10.6	7	15.6	18.8	18.9	98.9	38.4
Seed vigourI	both cut	2,771.30	2335.3	3526.3	8.4	9.3	81.5	15.7
Seed vigourII	both cut	920.5	593.9	1368.2	18.5	18.8	97.5	37.7
Electricalconductivity (dS/m/seed)	both cut	0.268	0.1	0.4	25.6	27.2	88.3	49.5

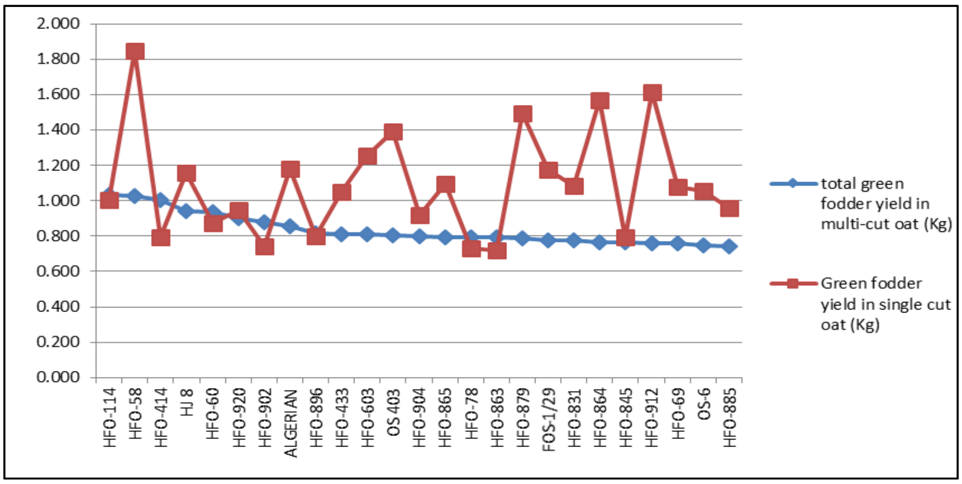

Fig 1: Mean performance of top 25 genotypes of oat for green fodder yield under single cut and multi-cut regimes

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