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Assessment of genetic parameters of oat varieties (*Avena sativa* L.) for fodder and grain yield

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Abstract
Twenty one released varieties of oat (*Avena sativa* L.) were evaluated during *Rabi* 2010-11 and *Rabi* 2011-12 for 16 morpho-physiological characteristics to assess the genetic variance, heritability and genetic advance for each character in the material. As per pooled over years analysis results revealed maximum genotypic coefficient of variation for grain yield per plant, harvest index, leaf: stem ratio, dry matter yield, green fodder yield and straw yield per plant. While high heritability and moderate to high genetic advance was observed for plant height, leaf length, leaf: stem ratio, number of spikelet, dry matter yield, green fodder yield, straw yield per plant, grain yield per plant and harvest index indicating the preponderance of additive genetic effects for these traits.

Keywords: Oat, variation, genetic advance, heritability

Introduction
Fodder crops are an important component of agricultural economy as they help sustainable development of livestock sector. Oat (*Avena sativa* L.) is a multipurpose winter cereal and forage crop grown 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 with high digestible dry matter and better net energy gain. Furthermore, the demand of oat for human consumption has increased, particularly because of the demonstrated dietary benefits of oat whole-grain products. 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. Genetic diversity is a prerequisite for an effective plant breeding programme. It is a useful and essential tool for parent's choice in hybridization nursery to develop high yielding potential cultivars and to meet the diversified goals of plant breeding suggested by Haydar *et al*. (2007) [5]. Hornokova *et al*. (2003) [6] stated that the knowledge of genetic diversity helps in the identification, differentiation and characterization of genotypes or populations. So it becomes important to exploit the germplasm and the material available to develop the new varieties for specific needs.

Materials and Methods
The experimental material consisted of 21 oat varieties. This was a diverse group comprising released and notified oat varieties collected from different SAUs and Research Institute from across the country. The field experiments were conducted at the Instructional Dairy Farm of G.B Pant University of Agriculture and Technology, Pantnagar in Randomized Block Design (RBD) with three replications during *Rabi* 2010-11 and *Rabi* 2011-12. Each replication composed of 21 plots and each plot had 2.5 meter long 5 rows spaced 40 cm apart. The plant to plant distance was maintained 10 cm apart by proper thinning of plants in the early growth stage. The distance between two plots was 150 cm. Observations were recorded on seven randomly selected representative plants from each plot in replication leaving the border rows. Data on 16 characters were recorded at different stages of plant growth. Average data of these seven plants were used for statistical analysis. Phenotypic and genotypic coefficients of variation were obtained as the ratio of respective standard deviation from the general mean of characters and expressed in per centage following Burton (1952) [3]. Heritability in broad sense and the expected genetic advance under selection for different characters were estimated as suggested by Allard (1960) [1].

Results and Discussion

Analysis of variance and Mean values

Analysis of variance for all the characters showed highly significant genetic variance among the varieties for all the characters under study during *Rabi* 2010-11, *Rabi* 2011-12 and in pooled analysis, indicating that there was enough variability found for these traits among the varieties. High genetic variance for morphological traits *viz.,* leaf number, green stem weight, panicle length, dry leaf and dry stem weight studied among the varieties in oat was also reported by Nehvi *et al*. (2007) [12] and Krishna *et al*. (2013) [9].

The mean values of 21 oat varieties for 16 characteristics along with standard error of mean and coefficient of variation are presented in Table. Mean performance of genotypes exhibited wide range of variation during both the season as well as in pooled analysis. As per pooled analysis, the wide range of variation for plant height (102.14- 153.00 cm), days to 50% heading stage (108.50 – 142.33 days), green fodder yield per meter row length (1.23 – 3.81 kg), leaf: stem ratio (0.23 – 0.67), days to maturity (155.00 – 176.00 days), grain yield per plant (4.77- 58.52 gm), 1000-grain weight (21.62 – 46.76 gm), harvest index (7.47 – 40.48 %) and crude protein content (13.20 – 17.77 %). Moderate to high range of variability for different traits *viz.,* plant height, number of tillers per plant, leaf length, leaf width, days to maturity, green fodder yield and grain yield per plant are in accordance with the findings of Gautam *et al*. (2006) [7], Sangwan *et al*. (2012) [14] in oat.

Coefficient of variation

Plant breeding is mainly the exploitation of genetic variation and in view of the possible decline of variation; breeders should always examine means of conserving variability and creating new germplasm. Information on genetic variability of yield and quality components is of paramount importance in crop improvement programme. The extent of genotypic variability indicates the amenability of given character for its improvement suggested by Burton and De Vane, (1953) [4]. The simple analysis of variance only signify the differences between treatments/ variety means as a whole without giving any idea about different components of this variation. Keeping this fact in view, the variation was partitioned into phenotypic, genotypic and environmental variances by estimating the phenotypic, genotypic and environmental coefficient of variation.

A comparative study of the genotypic, phenotypic and environmental coefficient of variation was measured in 21 varieties of oat in first year, second year and in pooled analysis has been presented in Table which revealed higher contribution of the genotypic variance in determining the phenotypic variance for most of the characters studied.

Based on the analysis during both the years, high estimates of PCV and GCV were substantial for most of the characters namely grain yield, green fodder yield, dry matter yield, straw yield, leaf: stem ratio, harvest index, and number of spikelet per panicle indicated reasonable higher variability in these traits which can be effectively improved through selection. On the other hand lower estimates of PCV and GCV for plant height, days to 50 % heading, tiller number per plant, leaf width and crude protein content showed moderate to low variability for these characteristics for which response to selection may be restricted to certain degree. The estimates of PCV were slightly higher than GCV for all the traits studied indicating little role of environment in the expression of these characters. Krishna *et al*. (2013) [9] in oat also reported higher value for most of the morphological traits namely plant height, leaf length green fodder yield, tiller number per plant, panicle length and grain yield showed higher value for PCV.

High estimates of GCV and PCV for days to 50% heading, tiller number per plant and dry matter yield have also been reported by Shankar *et al.* (2002) [15], Gautam *et al*. (2006) [7] and Sangwan *et al*. (2012) [14]. While the finding of high PCV and GCV values for number of leaves, grain yield per plant, harvest index, straw yield, panicle length and number of spikelet per panicle are in accordance with reports of Kumar *et al*. (2004) [10], Shekhawat *et al*. (2006) [16] and Sangwan *et al*. (2012) [14]. Appreciably high estimates of PCV and GCV indicated the presence of reasonably higher level of genetic variations suggesting the effectiveness of selection programmes for the improvement of these characters.

Heritability and Genetic advance

Knowledge of both heritability and genetic advance of a trait is necessary for deciding the scope of improvement through selection suggested by Johnson *et al.* (1955) [8]. The success of a breeding program mainly depends on the extent of additive genetic variance present in the breeding material for the concerned characters. Estimation of genetic advance and heritability is of prime importance in any selection programme which solely depends on additive genetic variance. Broad sense heritability estimates provides information on relative magnitude of genetic and environmental variation in germplasm pool.

Result of heritability and genetic advance for *Rabi* 2010-11, *Rabi* 2011-12 and in pooled over the years analysis (Table 1) revealed high to moderate estimates of heritability (h^2_b) for all the characters under study except crude protein content. In both the years, high estimates of heritability were recorded for plant height, leaf length, leaf width, green fodder yield, panicle length and days to 50% heading. Moderately high heritability were recorded for grain yield per plant, straw yield per plant, 1000-grain weight, spikelet per panicle, harvest index and dry matter yield. While the minimum value was recorded for crude protein content. These results on heritability are in accordance with the findings of Gautam *et al*. (2006) [7], Shekhawat *et al.* (2006) [16], Nehvi *et al*. (2007) [12], Bahadur and Choubey (2008) [2] and Roy *et al.* (2013) [13] in oat. Knowledge of heritability coupled with expected genetic advance of a trait is necessary for assessing the scope of improvement of character through selection. Expected genetic advance indicated the expected genetic progress for a particular trait under a suitable selection system.

Characters exhibited high estimates of heritability coupled with high to moderately high genetic advance were plant height, days to 50% heading, leaf length, leaf width, green fodder and dry matter yield, leaf: stem ratio, spikelet per panicle, grain yield per plant, straw yield per plant and harvest index. High genetic advance along with high heritability was observed in oat for biological yield by Mall *et al*. (2005) [11] for days to 50% heading and leaf: stem ratio by Shekhawat *et al*. (2006) [16] for green fodder yield, leaf: stem ratio, tillers per plant, leaf length and grain yield per plant by Gautam *et al*. (2006) [7] for plant height, leaf length, straw yield per plant by Roy *et al*. (2013) [13] for number of spikelets per panicle and 1000-grain weight by Shankar *et al*. (2002) [15]. Characters with high heritability along with high to moderately high genetic advance are genetically important traits as they can be improved easily through selection due to preponderance of additive genetic variance in the inheritance of these characters.

The overall results indicated the presence of adequate genetic variability among the varieties for most of the characters studied. The characters with appreciably high estimates of heritability couple with moderate to high genetic advance would be important traits in the development of improved oat cultivars through selection.

Table 1: Estimates of genetic parameters for forage yield and grain yield in 21 oat varieties

Characters / Parameters	Year	Range	Mean ± SE	CV (%)	Coefficient of Variation		h^2 (Broad sense)	Genetic advance (% of mean)
					PCV	GCV		
Plant height (cm)	2010-11	103.19 – 154.76	136.47 ± 1.49	1.93	8.15	7.92	94.37	15.84
	2011-12	102.14 – 153.00	135.12 ± 1.19	1.59	8.43	8.28	96.44	16.76
	Pooled	102.14 – 153.00	135.12 ± 1.57	2.05	8.60	8.35	94.30	16.71
Days to 50% heading (day)	2010-11	106.67 – 140.67	114.79 ± 2.00	3.09	7.92	7.29	84.71	13.82
	2011-12	110.33 – 144.00	117.52 ± 2.04	3.13	8.27	7.66	85.71	14.61
	Pooled	108.50 – 142.33	116.16 ± 2.07	3.17	8.13	7.48	84.79	14.19
Tillers per plant	2010-11	6.28 – 13.81	11.38 ± 0.69	10.77	17.15	13.34	60.53	21.38
	2011-12	6.33 – 13.24	11.02 ± 0.71	11.42	17.15	12.80	55.67	19.67
	Pooled	6.31 – 13.52	11.20 ± 0.67	10.58	16.95	13.24	61.04	21.31
Leaf length (cm)	2010-11	35.38 – 52.57	45.15 ± 0.81	3.16	11.03	10.57	91.81	20.86
	2011-12	34.90 – 50.53	44.10 ± 0.79	3.17	10.97	10.50	91.66	20.71
	Pooled	35.14 – 51.55	44.63 ± 0.71	3.03	11.14	10.72	92.59	21.25
Leaf width (cm)	2010-11	1.50 – 2.79	2.04 ± 0.07	5.85	15.28	14.11	85.33	26.85
	2011-12	1.63 – 2.65	1.99 ± 0.07	6.03	13.58	12.16	80.30	22.45
	Pooled	1.56 – 2.72	2.01 ± 0.06	5.45	14.49	13.42	85.84	25.62
Green fodder yield per meter row length (kg)	2010-11	1.21 – 3.82	2.04 ± 0.06	11.63	29.67	27.30	84.65	51.74
	2011-12	1.26 – 3.80	2.04 ± 0.13	11.74	29.09	26.61	83.71	50.16
	Pooled	1.23 – 3.81	2.04 ± 0.13	11.43	29.54	27.24	85.02	51.74
Dry matter yield per meter row length (kg)	2010-11	0.21 – 0.82	0.41 ± 0.04	15.36	32.63	28.79	77.80	52.34
	2011-12	0.21 – 0.83	0.42 ± 0.03	12.27	29.66	27.01	82.89	50.65
	pooled	0.30 – 0.83	0.42 ± 0.03	13.36	29.81	26.65	79.91	49.07
Leaf: Stem ratio	2010-11	0.22 – 0.66	0.39 ± 0.04	19.00	34.11	28.32	68.96	48.45
	2011-12	0.24 – 0.68	0.40 ± 0.04	16.86	33.01	28.38	73.92	50.27
	Pooled	0.23 – 0.67	0.39 ± 0.04	18.09	33.03	27.64	70.01	47.63

Table 1: Cont ……..

Characters / Parameters	Year	Range	Mean ± SE	CV (%)	Coefficient of Variation		h^2 (Broad sense)	Genetic advance (% of mean)
					GCV	PCV		
Panicle Length (cm)	2010-11	36.28 – 56.83	50.73 ± 0.76	1.46	10.30	9.66	87.98	18.66
	2011-12	39.00 – 55.40	50.79 ± 0.81	1.54	10.39	9.65	86.37	18.48
	Pooled	37.64 – 54.81	50.76 ± 0.83	1.56	10.79	9.97	85.29	18.96
Spikelet per panicle	2010-11	49.76 – 118.81	89.66 ± 5.27	3.57	22.73	20.20	79.02	36.99
	2011-12	47.57 – 116.86	88.24 ± 5.14	3.83	22.75	20.35	80.02	37.51
	Pooled	48.67 – 117.83	88.95 ± 5.25	4.14	22.75	20.24	79.15	37.09
Days to maturity (day)	2010-11	155.33 – 177.00	165.06 ± 1.36	10.41	3.74	3.44	84.80	6.53
	2011-12	154.67 – 175.00	165.13 ± 1.44	10.17	3.76	3.43	83.16	6.44
	Pooled	155.00 – 176.00	165.10 ± 1.46	10.39	3.74	3.40	82.49	6.36
Grain yield per plant (gm)	2010-11	3.82 – 59.28	24.56 ± 2.86	20.74	48.42	43.75	81.64	41.90
	2011-12	5.72 – 57.76	24.30 ± 2.76	20.06	48.37	44.01	82.79	42.45
	Pooled	4.77 – 58.52	24.43 ± 2.94	21.34	48.82	43.91	80.89	41.87
Straw yield per plant (gm)	2010-11	55.99 – 155.29	103.57± 6.86	11.79	25.73	22.86	78.99	41.86
	2011-12	53.99 – 154.71	103.49 ± 6.38	10.94	25.34	22.86	81.38	42.49
	Pooled	54.99 – 155.00	103.53 ± 6.81	11.70	25.57	22.74	79.07	41.65
1000- Grain weight (gm)	2010-11	21.58 – 46.99	37.10 ± 1.88	9.06	17.48	14.79	72.71	25.98
	2011-12	21.66 – 46.53	36.47 ± 1.89	9.08	17.48	14.93	73.03	26.29
	Pooled	21.62 – 46.76	36.79 ± 1.99	9.57	17.78	14.98	71.02	26.01
Harvest index (%)	2010-11	6.61 – 40.80	19.55 ± 2.18	19.92	42.50	37.42	77.93	68.07
	2011-12	7.49 – 40.17	19.65 ± 2.21	20.11	42.50	37.44	77.62	67.95
	pooled	7.47 – 40.48	19.60 ± 2.23	20.49	42.06	36.74	76.28	66.09
Crude Protein content (%)	2010-11	12.87 – 17.99	15.63 ± 0.76	8.61	12.61	8.10	46.94	11.43
	2011-12	13.21 – 17.56	15.27 ± 0.91	10.38	12.61	7.17	32.27	8.38
	Pooled	13.20 – 17.77	15.45 ± 0.98	11.18	13.25	7.11	28.79	7.86

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