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Genetic variability and character association analyses among yield and yield contributing traits in oats (*Avena sativa* L.)

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Abstract
Twenty five oat (*Avena sativa* L.) strains were evaluated morphologically for days to flowering, days to maturity, fresh green weight per plant (g), total number of tillers per plant, plant height (cm), leaf length (cm), leaf width (cm) leaves per plant, nodes per plant, biological yield per plant (g) and seed yield per plant (g) to evaluate the genetic variance, heritability and genetic advance and character association for each character in the materials. Analysis of variance revealed significant variation exists among the stains for all characters studied. The estimation of genotypic coefficient of variation and phenotypic coefficient of variation were high for total number of tillers per plant, 100-seed weight, fresh green weight, and seed yield per plant. High heritability along with high genetic advance as percent of mean were observed for fresh green weight per plant, total number of number tillers per plant and seed yield per plant. Seed yield per plant exhibited significant positive association with leaf length, days to maturity and plant height. It was concluded that leaf length, days to maturity and plant height are major yield contributing characters in selecting high yielding oats stains. This investigation exhibited that there exists a wide range of genetic variability among oats strains for most of the characters which would be useful for direct selection of high yielding strains.

Keywords: Genetic advance, heritability, oats

Introduction
Oat (*Avena sativa* L. 2n= 6x = 42) a constituent of family *poaceae* has been used as grain and fodder as it's a good source of protein, fiber and minerals. It is used as green crop, hay and silage for animal feed alone or in mixture feed to dairy cattle, horses, mules and turkeys, with lesser quantities feed to hogs, beef cattle and sheep. India is increasing on a fast scale as oat meal, oat granola, baby food and breakfast cereal. Oats have adequate soluble carbohydrates to make good silage. Oat in small bags is very popular in hilly areas. The oat is grown in several parts of India and abroad. It is mainly grown in *rabi* season mostly for fodder, however, of late, its grain is being used as baby food, breakfast food and animal feed. Oat is a versatile grain for food, animal feed and non food products due to its unique grain qualities compared to other cereal grains. India possesses a large bovine population which includes 200 million cattle and 92 million buffalo. This accounts for 19.5 percent of the global cattle population. Despite this large bovine population, the scenario of milk production and productivity is far below the world average. The total area covered under oat cultivation in the country is about 5,00,000 ha. It is also used as medicinal ingredient to protect against cancers and heart diseases, enhance immune response to infection, stabilize blood sugar, smooth skin conditions and other ailments, as well as use as an antispasmodic, a diuretic, an emollient, a nerve tonic, a supplement, an aphrodisiac, and a stimulant. Seed yield is a complex character and an interactive effect/contribution of different traits. Therefore, for any crop improvement programme through selection, the study of genetic variability and heritability together with genetic advance is necessary. So the development of high yielding varieties of oats for grain and forage yield requires the implication of crop improvement to stable the superior genotype or initiating a breeding programme based on the yield components. From the plant breeder's view point, genetic variation for yield and its components is important but evaluation of traits relationships are necessary for better understanding and developing of breeding programme. Assessment of the genetic variability and character association can be achieved by using morphological measurements and phenotypic characterization.

Materials and Methods

The present study was conducted at the Students Instructional Farm of Chandra shekhar Azad University of Agriculture and Technology, Kanpur during *Rabi* season of 2015-16. A set of 25 oats genotypes were evaluated in Randomized Complete Block Design (RBD) with three replications. Observations were recorded on five randomly selected representative plants from each replication leaving the border rows, for days to flowering, days to maturity, fresh green weight per plant(g), total number of tillers per plant, plant height(cm),leaf length(cm),leaf width(cm),number of leaves per plant, number of nodes per plant, biological yield per plant(g) and seed yield per plant (g). Average data of these selected five plants were used for statistical analysis. The calculation of variability parameters were quantified according to the statistical method advocated by Lush (1940). Phenotypic and genotypic coefficients of variation were estimated based on tan approach suggested by Burton (1952) [5]. Heritability in broad sense was calculated by Allard (1960) [1] and genetic advance as percent of mean was estimated by method cracked was Johanson *et. al*.,(1955) [9]. Character association analysis at genotypic, phenotypic levels for seed yield per plant was taken as the dependent variable while the rest of the traits were considered as independent variables by the simultaneous solution of the formula suggested by Dewey and Lu (1959) [7].

Result and Discussion

The analysis of variance revealed a significant variation among genotypes for all traits under investigation. The average values, range and phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), heritability, genetic advance as percent of mean are mentioned in Table 1 and 2. Phenotypic coefficient of variation (PCV) estimates was found higher than the genotypic coefficients of variation (GCV) for all twelve traits studied. High estimates of GCV and PCV for fresh green weight per plant (g), total number of tillers per plant and seed yield per plant. This result was in agreement with the earlier reports of Revathi, (2016) [14] and Kumar *et.al.,* (2017) [13].This indicates a high level of genetic variation plays for the expression of characters suggesting the effectiveness of selection programs improvement of these traits.

The success in any breeding program is based on the spectrum of genetic variability present in breeding material for concerned traits. Estimation of heritability and genetic advance is of prime importance in any selection program which solely depends on additive genetic variance. The high heritability along with high genetic advance as percent of mean estimates were observed for fresh green weight per plant, total number of tillers per plant, and seed yield per plant. These results were in agreement with Bibi, (2012) [3]; Sangwan, *et.al.,* (2012) [15]; Ahmed *et. al.,* (2013) [2]; Krishna *et.al.,* (2013); Chandan *et.al.,* (2013) [6]; Bind, *et.al*., (2016) [4]; Kumar *et. al.,* (2017) [13].These results indicates the presence of high additive genetic variance for these traits in the genotypes of crop used as breeding material. High GCV, heritability and genetic advance provide better information on simple selection that these traits would be useful for an improvement of seed yield per plant in the genotype of oats. However, all the traits studied except leaves per plant and nodes per plant were found to have high heritability but with a law to moderate magnitude of genetic advance also reported similar findings for estimates of heritability and genetic advance for these most of traits by Krishna *et.al.,* (2013); Chandan *et.al.,* (2013) [6]; Kumar *et. al.*,(2017) [13]. Estimation of phenotypic and genotypic correlation coefficients between each pair of traits is present in Table-3. The result exhibited that in most cases, the genotypic correlation coefficient were higher than the phenotypic correlation coefficients, which is indication of the inherent association among various traits independent of environmental influence. Seed yield per plant showed maximum positive and significant association with leaf length, days to maturity, plant height and biological yield per plant at phenotypic and genotypic levels. These findings were similar to Bibi *et.al.,* (2012) [3]; Tewari and Pandey (2014) [16], Krishna *et al.* (2014) [11], Jaipal and Shekhawat (2016) [10], and Kumar *et al.* (2017) [13].

Perusal on correlation among component traits revealed that strong association among desirable component traits are present especially with leaf length, days to maturity, plant height, and biological yield per plant Hence, selection criteria should be consider all these traits for seed yield improvement. Undesirable relationship of the component traits might act as deterrent for the formulation of a comprehensive selection program involving these factors. Therefore, while formulating a comprehensive selection program these traits must be considered with a caution

Table 1: Analysis of variance (ANOVA) for twelve characters of oat (*Avena sativa* L.)

Source of variation	D.F	DF	DM	FGWP	TPP	PH (cm)	LL(cm)	LW(cm)	LPP	NPP	BYPP(g)	GPP	SYPP(g)
Replication	2	8.28	7.37	455.87	1.04	364.68	10.78	17.62	4.85	7.84	6.76	29.89	6.88
Treatment	24	22.14**	9.49**	2420.57**	7.58**	157.07**	110.11**	1.42**	2.12**	2.10**	2.34**	71.48**	3..51**
Error	48	0.14	3.47	46.25	0.46	16.63	4.00	14.32	1.90	1.25	2.24	1.10	62.05

*, **significant at 5% and 1% level, respectively

DF- Days to flowering
DM- Days to maturity
FGWP- Fresh green weight per plant (g)
TPP- Tillers per plant
PH- Plant Height
LL- Leaf length (cm)
LW- Leaf width (cm)
LPP- Leaves per plant
NPP- Nodes per plant**S**
BYPP- Biological Yield per plant (g)
GPP- Grains Per plant
YPP- Seed yield per plant (g)

Table 2: Estimates of variability parameters for twelve characters in oat (*Avena sativa* L.)

Characters	Mean	Range	PCV (%)	GCV (%)	h^2	Genetic Advance	GA as percent of mean
DF	85.59	80.33-87.13	3.20	3.16	98.00	5.52	6.44
DM	119.54	116-121.40	1.49	1.49	98.90	3.64	3.04
FGWP	127.45	76.40-188.13	22.71	22.07	94.50	56.33	44.19
TPP	9.62	6.00-11.67	27.51	26.01	83.60	22.90	30.14
PH	139.27	127.60-154.67	5.72	4.19	73.80	12.11	8.69
LL	75.27	56.13-81.47	8.34	7.90	89.80	11.61	15.42
LW	1.46	1.35-1.59	5.14	4.45	74.80	0.12	8.21
LPP	5.10	4.80-5.60	4.58	3.69	65.00	0.31	6.07
NPP	5.10	4.80- 5.53	4.02	3.37	70.10	0.30	5.88
BYPP	11.21	9.93-13.07	7.96	7.85	97.20	1.79	15.96
GPP	86.14	75.73-96.27	25.75	25.62	95.50	29.75	31.30
SYPP	3.79	3.24-4.89	21.06	20.87	96.50	20.83	21.89

Table 3: Estimates of correlation coefficient for genotypic (G) and phenotypic (P) levels among different characters in oat (*Avena sativa* L.)

Characters		DF	DM	FGWP	TPP	PH	LL	LW	LPP	NPP	BYPP	GPP	SYPP
DF	G	-	-0.016	-0.282	-0.332*	0.051	-0.319	0.177	-.340	-0.305	-0.354	-0.142	0.054
	P		-0.016	-0.270	-.309*	0.018	-0.283	0.158	-0.264	-0.268	-0.356	-0.132	0.060
DM	G			-0.404*	-0.276	-0.098	0.397	-0.168	0.024	0.091	0.218	0.172	0.416*
	P			-0.383*	-0.247	-0.078	0.374	-0.131	0.014	0.067	0.213	0.170	0.405*
FGWP	G				0.718**	0.419*	-0.029	0.045	0.059	0.080	-0.456	-0.109	-0.136
	P				0.649**	0.327*	-0.007	0.085	0.062	0.060	-0.434	-0.094	-0.134
TPP	G					0.166	-0.031	0.041	0.079	0.090	-0.429	-0.120	-0.109
	P					0.116	-0.040	0.076	0.071	0.059	-0.369	-0.111	-0.105
PH	G						-0.225	0.245	-0.187	-0.211	-0.279	-0.097	0.363**
	P						-0.201	0.113	-0.137	-0.111	-0.214	-0.085	0.354**
LL	G							-0.316	0.146	0.238	0.152	-0.201	0.516**
	P							-0.221	0.154	0.220	0.133	-0.158	0.489**
LW	G								-0.393	-0.326	-0.140	-0.192	-0.001
	P								-0.310	-0.258	-0.125	-0.153	-0.005
LPP	G									0.070	0.102	0.250	0.245
	P									0.787	0.106	0.220	0.210
NPP	G										0.151	0.191	-0.180
	P										0.156	0.187	-0.154
BYPP	G											0.393*	0.358**
	P											0.379*	0.344**
GPP	G												0.364**
	P												0.368**

*,**significant at 5% and 1% level, respectively

DF- Days to flowering **TPP**- Tillers per plant **LW**- Leaf width (cm) **BYPP**- Biological Yield per plant (g)
DM- Days to maturity **PH**- Plant Height **LPP**- Leaves per plant **GPP**- Grains Per plant
FGWP- Fresh green weight per plant (g) **LL**- Leaf length (cm) **NPP**- Nodes per plant **SYPP**- Seed yield per plant (g)

Table 4: Path coefficient analysis showing the direct and indirect effects of twelve characters on the seed yield at genotypic level of oat (*Avena sativa* L.)

Characters		DF	DM	FGWP	TPP	PH	LL	LW	LPP	NPP	BYPP	GPP	SYPP
DF	G	0.319	-0.001	0.045	-0.076	0.013	-0.263	0.026	0.063	0.029	-0.037	-0.064	0.054
DM	G	-0.005	0.053	0.064	-0.063	-0.024	0.328	-0.025	-0.004	-0.009	0.023	0.078	0.416**
FGWP	G	-0.090	-0.021	-0.159	0.163	0104	-0.024	0.007	-0.011	-0.007	-0.048	-0.049	-0.136
TPP	G	-0.106	-0.015	-0.114	0.227	0.041	-0.025	0.006	-0.015	-0.008	-0.045	-0.054	-0.109
PH	G	0.016	-0.005	-0.067	0.038	0.249	-0.186	0.036	0.035	0.020	-0.029	-0.044	0.363**
LL	G	-0.102	0.021	0.005	-0.007	-0.056	0.826	-0.046	-0.027	-0.022	0.016	-0.091	0.516**
LW	G	0.057	-0.009	-0.007	0.009	0.069	-0.261	0.147	0.073	0.031	-0.015	-0.087	-0.001
LPP	G	-0.108	0.001	-0.009	0.018	-0.047	0.121	-0.058	-0.186	-0.100	0.011	0.113	0.245
NPP	G	-0.097	0.005	-0.013	0.021	-0.053	0.196	-0.048	-0.199	-0.094	0.016	0.086	-0.180
BYPP	G	-0.113	0.012	0.073	-0.097	-0.069	0.126	-0.021	-0.019	-0.014	0.104	0.178	0.358**
GPP	G	-0.045	0.009	0.017	-0.027	-0.024	-0.166	-0.028	-0.047	-0.018	0.041	0.453	0.364**

*,**significant at 5% and 1% level, respectively Residual values (G)= 0.36 *,**significant at 5% and 1% level, respectively
Bold value indicate direct effects

DF- Days to flowering **TPP**- Tillers per plant **LW**- Leaf width (cm) **BYPP**- Biological Yield per plant (g)
DM- Days to maturity **PH**- Plant Height **LPP**- Leaves per plant **GPP**- Grains Per plant
FGWP- Fresh green weight per plant (g) **LL**- Leaf length (cm) **NPP**- Nodes per plant **SYPP**- Seed yield per plant (g)

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