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Analysis of variability, association and effects of direct and indirect on quantitative traits in oats (*Avena sativa* L.)

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Abstract
Twenty five oats genotypes were grown in randomized completely block design (RCBD) and evaluated for eleven characters. The genotypes showed significant differences between all the characters. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) estimates were high for seed yield per plant followed by seeds per plant, fresh green weight per plant, total number of tillers per plant. Heritability was high for most of the characters. Genetic advance (GA) was high for fresh green weight per plant (g) followed spike length and seeds per plant. Moderate to high heritability accompanied with high genetic advance for fresh green weight per plant (g) followed spike length and seeds per plant indicated additive gene action and selection for these characters would be effective. Harvest index, leaf width, seeds per plant and biological yield per plant had high positive correlation with seed yield per plant. Leaves per plant and leaf width had high positive direct effect on seed yield and indirect positive effect via these two traits greatly influenced positive association of other traits with seed yield. Total number of tillers per plant and days to flowering had moderate positive direct effect on seed yield. The remaining two component traits had very low direct effect on seed yield. The character association and path analysis study revealed that selection for harvest index and lead width would be highly effective in bringing out improvement in seed yield. Selection for biological yield per plant and seeds per plant would result in some improvement in yield. This study showed that there exists a large genetic variation among oats genotypes for most of the traits which could be exploited for direct selection of high yielding genotypes. Finally expect that these novel strains of oats which is suitable to winter growing should be useful for plain condition.

Keywords: Oats, genetic parameter, character association and path analysis, genotypes

Introduction
Oat is considered to be a potential source of low cost protein with good nutritional value. Oat has a unique protein composition along with high protein content of 11–15 %. Cereal proteins have been classified into four types according to their solubility as follows: albumins (water soluble), globulins (salt water soluble), prolamins (soluble in dilute alcohol solution) and glutamines (soluble in acids or bases). Oat protein not only differs in the structural properties but also differs in distribution of protein fraction in comparison to other cereal grains. Other cereals such as wheat and barley have characteristic protein matrix which lacks in oat. In wheat and some other cereals, the storage protein is insoluble in salt solutions, while in oats, a large portion of salt water soluble globulins also belong to the storage proteins of the endosperm (Klose *et al.* 2009) [7]. Yield is a complex character which is contributed by a large number of component traits. Therefore, to determine the relative importance of the component characters and to initiate an effective selection programme, correlation studies are practiced. The traits contributing significantly towards yield could be identified and used as base for alternative selection criteria for forage yield improvement. In forage oat, dry fodder yield is an important character on which animal performance is dependent. Hence, dry fodder yield per meter row length was taken as dependent character for correlation studies in this investigation. Simple correlation coefficients provide association (positive and negative) between characters but it does not give causal basis of such associations. Path analysis provides the information on direct and indirect effects of various independent components on the dependent character. Both green and dry fodder yield are equally important if we consider morphological characters, however, in case of animal performance and their body maintenance, dry fodder

yield is more important. Thus in present study path coefficient analysis was done considering dry fodder yield as a dependent character Poonia *et al*., (2017) [9].

Materials and Methods

Plant materials comprised of 25 genotypes, were sown directly in the main field with spacing of 2 m x 2 m on 1st week of November 2017-18 The experiment was conducted in a randomized completely block design with three replications at Student Instructional Farm, CSAUAT, Kanpur. This study is on the 1 year observations on days to flowering, fresh green weight of total per plant (g), total numbers of tillers per plant, leaf length (cm), leaf width (cm), leaves per plant, biological yield per plant (g), seeds per plant, harvest index and seed yield per plant (g) were recorded on 5 random competitive plants per plot. The observations on the 11 traits were statistically analyzed according RCBD. Genetic variability parameters, heritability and genetic advance of the traits were estimated according to formulae of AlJibouri *et al.,* 1958. The phenotypic correlation between pairs of characters were computed according to formulae suggested by Robinson *et al.,* 1958 [2] and the correlations of the component traits with yield was partitioned into direct and indirect effects by path co-efficient analysis following Dewey and Lu 1959 [5].

Result and Discussion

Analysis of variance revealed significant differences exists among the genotypes for all the characters studied. The mean, range and estimates of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability in broad sense (h^2 in bs) and genetic advance as per cent of mean (GA) are presented in Table 1. Days to flowering showed a range of 83.93 to 101.80 with a mean of 93.81. Estimates of phenotypic and genotypic coefficients of variation for this character were 4.92 and 4.89 per cent respectively. Fresh green weight of total tiller per plant exhibited a range of 82.60 to 221.60 g with a mean of 151.84g. Among all the accessions studied. Muhammad *et al*., (2002), and Bibi *et al*., (2012) [3] Krishna *et al*., (2013) [8] and Singh *et al*., (2018) [12, 13] reported significant difference for plant height in oats genotypes which agreed with the present findings. This character recorded phenotypic and genotypic coefficients of variation of 23.08 and 21.67 per cent respectively. Total number of tillers per plant varied from 8.53 to 20.13 with a mean of 14.40 among the accessions. Estimates of phenotypic and genotypic coefficients of variation for leaf length were 8.39 and 8.07 per cent respectively. This character showed a range of 35.87 – 50.07cm with a mean of 44.42 among the accessions. Leaf width varied from 1.48 to 1.77 cm with a mean of 1.66 cm and this character recorded phenotypic and genotypic coefficients of variation of 5.74 and 5.36 per cent respectively. Estimates of phenotypic and genotypic coefficients of variation were 3.26 and 3.20 per cent respectively for leaves per plant and ranged from 5.20 to 5.47 with a mean of 5.34. The accessions, the most genotypes were recorded the highest number of leaves per plant. The Phenotypic and genotypic coefficients of variation for biological yield pr plant were 6.84 and 6.71 per cent respectively and ranged from 12.53 to16.33 g with a mean of 14.22g. Seeds per plant ranged from 86.40 to 106.20 with a mean of 95.97 with Phenotypic and genotypic coefficients of variation estimates for this character were 25.28 and 25.19 per cent respectively. Phenotypic and genotypic coefficients of variation estimates for harvest index were 11.35 and 11.10 per cent respectively and ranged from 25.75 to 37.72 with a mean of 29.68 per cent. The accessions, in the character of spike length the phenotypic and genotypic coefficients of variation were 12.57 and 12.25 per cent respectively with showed a range of 17.13 to 29.05 cm and mean of 26.69 cm. Single plant of oat genotype the yield range varied between 3.68 to 5.34g with a mean of 4.20g. The accessions, most of the genotypes showed highest seed yield per plant. Estimates of phenotypic and genotypic coefficients of variation for this character were 30.10 and 29.88 per cent respectively. This high account of variability notified for all the characters showed the possible productivity improvement in oats by direct selection among different genotypes.

Heritability and genetic advance

The success in any breeding programmed depends on the spectrum of genetic variability present in the germplasms. 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) [6]. The broad sense heritability gives an idea about the portion of observed variability attributable to genetic difference. Heritability indicates the accuracy with which a genotype can be identified by its phenotypic performance. Burton (1952) [4] suggested that heritability estimates coupled with genotypic coefficient of variation would provide an accurate picture about the extent of genetic advance to be expected through selection. The highest heritability and genetic advance estimates were recorded for the all the characters except leaves per plant (Table 2). The higher estimate of heritability indicated the selection of these traits may be helpful for the improvement of yield. These findings were in agreement with Ahmed *et al.,* (2013) [1] and Krishna *et al.,* (2013) [4], Premkumar *et al*., (2017) [10] and Singh *et al*., (2018) [12, 13],

Correlation and path analysis between seed yield and its component characters

Seed yield per plant showed positive and significant correlation with harvest index (0.824, 0.793), leaf width (0.562, 0.482), seeds per plant (0.358, 0.351) and biological yield per plant (0.325, 0.324) at phenotypic and genotypic levels respectively. The result indicated that by improving these characters green fodder yield may be enhanced in this crop. These result are in general agreement with the finding of Krishna *et al*., (2013) [8], Premshankar *et al.,* (2017), and Singh *et al*. (2018) [12, 13], and thus, it can be inferred that selection based on any one of these traits either alone or in combination, will result in identifying high yielding strains. The above result suggested the possibility of selection of one of the above component character would result in the improvement of other characters. High indirect positive contribution of harvest index through days to flowering, total number of tiller per plant and leave per plant; Leaf width via fresh green weight per plant; seeds per plant through leaf length and fresh green weight per plant; Biological yield per plant through fresh green weight per plant, leaf length and leaf weight were responsible for their positive association with seed yield per plant. These results are in general agreement with the findings of Poonia *et al.,* (2017) [9] and Singh *et al.* (2018) [12, 13] and. The contribution of residual effects that influenced green fodder yield was very low at both genotypic and phenotypic levels, indicating that these traits included in the present investigation were sufficient enough to account for the variability in the dependant character i.e. seed yield per plant. From the overall study,

there is an indication of improvement in yield through selection with high values for biological yield per plant and seeds per plant. Hence, selection criteria should consider all these characters for the improvement of seed yield. Undesirable association of some of the component characters might act as deterrent for the formulation of a comprehensive selection programme involving these traits. So, while formulating a comprehensive selection programme, these factors must be considered with a caution.

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

Source of variation	d. f	Days to flowering	Fresh green weight per plant (g)	Total Numbers of Tillers per plant	Leaf length (cm)	Leaf Width (cm)	Leaves per plant	Biological yield per plant(g)	Seeds per Plant	Harvest Index	Spike length (cm)	Seed yield per plant(g)
Replication	2	5.43	128.87	0.19	1.95	19.58	13.91	7.43	25.43	15.42	17.45	4.80
Treatment	24	63.40**	3392.82**	26.52**	2.50**	25.04**	21.45**	2.76**	75.37**	33.05**	30.25**	2.52**
Error	48	0.28	145.5	12.69	11.80	011.80	41.48	3.64	0.81	0.52	0.51	76.56

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

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

Characters	Mean	Range	PCV (%)	GCV (%)	Heritability(bs)	Genetic Advance	GA as percent of mean
Days to flowering	93.81	83.93-101.8	4.92	4.89	98.70	9.39	10.00
Fresh green weight per plant (g)	151.84	82.60-221.60	23.08	21.67	88.10	63.63	41.90
Total Numbers of Tillers per plant	14.40	8.53-20.13	21.61	20.15	86.90	5.57	38.68
Leaf length (cm)	44.42	35.87-50.07	8.39	8.07	92.40	9.10	35.98
Leaf width (cm)	1.66	1.48-1.77	5.74	5.36	87.10	0.17	10.24
Leaves per plant	5.34	5.20-5.47	3.26	3.20	3.30	0.12	0.18
Biological yield per plant(g)	14.22	12.53-16.33	6.84	6.71	96.10	1.93	13.57
Seeds per Plant	95.97	86.40-106.20	25.28	25.19	96.80	26.11	30.53
Harvest Index	29.68	25.75-37.72	11.35	11.10	95.60	6.63	22.23
Spike length(cm)	26.69	17.13-29.05	12.57	12.25	95.10	30.32	24.60
Seed yield per plant(g)	4.20	3.68-5.34	30.10	29.88	95.80	0.84	30.00

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

Characters		Days to flowering	Fresh green weight per plant (g)	Total Numbers of Tillers per plant	Leaf length (cm)	Leaf width (cm)	Leaves per plant	Biological yield per plant(g)	Seeds per Plant	Harvest Index	Spike length(cm)	Seed yield per plant(g)
Days to flowering	G	-	-0..184	-0.214	0.175	0.069	0.568**	0.002	0.070	0.124	0.075	0.134
	P		-0.164	-0.193	0.163	0.053	0.522**	-0.002	0.068	0.120	0.070	0.127
Fresh green weight per plant (g)	G			0.780**	0.252	-0.144	-0.598**	-0.515**	-0.196	0.184	-0.012	-0.118
	P			0.756**	0.239	-0.135	-0.501**	-0.475**	-0.173	0.167	-0.013	-0.113
Total Numbers of Tillers per plant	G				0.326*	-0.235	-0.226	-0.500**	-0.164	0.299	-0.009	-0.002
	P				0.302*	-0.217	0.151	-0.452**	-0.154	0.263	-0.008	-0.026
Leaf length (cm)	G					0.094	0.384**	-0.412**	-0.458**	0.125	-0.018	-0.181
	P					0.115	0.359*	-0.373*	-0.397**	0.096	-0.009	-0.166
Leaf width (cm)	G						-0.100	0.206	0.151	-0.598**	0.084	0.562**
	P						-0.047	0.196	0.146	-0.543**	0.089	0.482**
Leaves per plant	G							-0.180	-0.012	0.039**	0.315*	0.068
	P							-0.150	-0.042	0.033	0.225*	0.067
Biological yield per plant(g)	G								0.357*	-0.441**	0.115	0.325*
	P								0.351*	-0.434**	0.110	0.324*
Seeds per Plant	G									-0.032	0.533**	0.351**
	P									-0.028	0.512**	0.358**
Harvest Index	G										-0.093	0.824**
	P										-0.085	0.793**
Spike length(cm)	G											0.026
	P											0.028
Seed yield per plant(g)	G											-
	P											-

*significant at P=0.05 and**significant p= 0.01.

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

Characters		Days to flowering	Fresh green weight per plant (g)	Total Numbers of Tillers per plant	Leaf length (cm))	Leaf width (cm)	Leaves per plant	Biological yield per plant(g)	Seeds per Plant	Harvest Index	PL(cm)	Seed yield per plant(g)
Days to flowering	G	0.275	0.136	-0.064	-0.118	0.042	0.454	0.000	-0.011	0.522	0.008	0.134
Fresh green weight per plant (g)	G	-0.050	-0.740	0.231	-0.170	-0.089	-0.303	-0.055	0.032	0.771	-0.001	-0.118
Total Numbers of Tillers per plant	G	-0.059	-0.577	0.296	-0.220	-0.145	-0.071	-0.053	0.027	0.253	-0.001	0.002
Leaf length (cm)	G	0.048	-0.186	0.097	-0.675	0.058	0.278	-0.044	0.074	0.523	-0.002	-0.181
Leaf width (cm)	G	0.019	0.106	-0.070	-0.063	0.618	-0.132	0.022	-0.025	-0.512	0.009	0.562**
Leaves per plant	G	0.069	0.125	-0.012	-0.105	-0.045	0.796	-0.019	0.002	0.164	0.033	0.068
Biological yield per plant(g)	G	0.000	0.381	-0.148	0.278	0.127	-0.323	0.106	0.058	-0.850	0.012	0.325*
Seeds per Plant	G	0.019	0.145	-0.048	0.309	0.093	-.022	0.038	-0.162	-0.133	0.055	0.351*
Harvest Index	G	0.034	-0.136	0.088	-0.084	-0.370	0.070	-.047	0.005	0.198	0.010	0.824**
Spike length(cm)	G	0.21	0.009	-0.003	0.012	0.052	0.567	0.012	-0.086	-0.389	0.104	0.026

Significant at P=0.05 and**significant p= 0.01.
Residual values (G)=0.021 Bold value indicate direct effects

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