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GENETIC CHARACTERIZATION AND INHERITANCE STUDIES OF OATS (*AVENA SATIVA* L.) FOR GREEN FODDER YIELD

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ABSTRACT

One hundred and eight accessions of oats (*Avena sativa* L.) including five check arieties were evaluated for green fodder yield during 2011 following Augmented design. The highest values of genotypic variance, phenotypic variance, genotypic and phenotypic coefficient of variance were recorded for number of tillers per meter row while lowest for number of leaves per plant. The highest heritability estimates were recorded for almost all traits. Inter nodal length, leaf area, number of tillers and dry matter yield had positive and significant correlation with green fodder yield. Whereas, days to 50% flowering, days to 50% maturity and plant height had a negative and non-significant correlation with green fodder yield.

Keywords: Oat, *Avena sativa*, Augmented Design, Correlation Coefficients, Heritability, Fodder

INTRODUCTION

Livestock is vital sub-sector of agriculture in Pakistan and 35 million of rural population is directly involved in livestock **[1]**. It provides milk, meat and other products of animal origin for human nutrition. The consumption and demand of livestock byproducts (meat, beef, milk, butter and other byproducts) is increasing day by day due to rapidly growing human population in Pakistan **[2]**. Availability of good quality forage along with sufficient quantity is essential to maintain high levels of milk and meat production **[3]**.

Existing livestock of the country is not producing up to their optimum potential and Government of Pakistan has to spend more than 800 billion rupees on the import of milk and meat products **[1]**. Fodder production is a major limiting factor as adequate amount of fodder is not available in terms of quantity and quality. Animals in Pakistan are deficient both in energy and protein by 40 and 60%, respectively [**4, 5]**. [**6]** stated that available fodder supply is 1/3 less than the actual needs of animals in Pakistan. This under fed and under nourished livestock results in their poor performance. Under the circumstances of shortage of fodder and seed of fodder crops, there is a dire need to fill the gap between the demands and supply of fodder and of fodder crops. It is only possible through the evolution of high yielding cultivars of different fodder crops. Cultivation and production of fodder is mainly climate dependent such as temperature, photoperiod, day length, and accessibility of water and allocation of rainfall [**7]**.

Oats (*Avena sativa* L.) are Asiatic in origin and rank fourth in terms of world production of cereals [**8]**. Forage oats (*Avena sativa* L.) are grown throughout Pakistan in winter under a wide variety of soil and climatic conditions. Oat is an important winter fodder, mostly fed as green but surplus is converted into silage or hay to use during fodder deficit periods **[9, 10]**.

Farmers have to face acute shortage of green fodder in Pakistan is during mid November to mid January when there are only dry stalks of dry cereal fodders or dry summer grasses. Oat has genetic potential to produce three-fold green fodder, that is, 60 to 80 tones/ha and can feed double number of animals per unit area as against the traditional fodder crops [**11]**. Oats can provide green fodder after 60-70 days in an emergency to tide over the scarcity period. With the introduction of new high yielding oat varieties, the farmers in KPK have recognized oat as important winter fodder for filling the fodder gap [**12]**. Many cultivars of oat have high feed value if cut at flowering stage or soon after it and can meet the demand of rapidly growing livestock industry of Pakistan [**3]**. Ideal variety is always one, which possesses general adaptation with higher yield potential [**13, 14]**. Oats are mostly fed green and surplus is made into hay. It is high in total digestible nutrients (TDN), protein, fat, vitamin B_1 and minerals i.e. phosphorus and iron [**15]**. It is a favorite feed of all animals and the straw is soft and much superior to wheat and barley. It is a quick growing, palatable, succulent and nutritious crop and forms an excellent combination when fed along with cold season legumes, like Berseem or Egyptian clover, alfalfa, Indian clover, Persian clover, pea or vetch [**3**]. Over the past two decades selected oat cultivars have had a significant impact in enhancing livestock feed in Pakistan. It has stimulated the belief that even more should be done both to make existing cultivars more widely available and to introduce new adapted oats cultivars and other improved fodder crop varieties. Keeping in view the shortage of green fodder, a field experiment of one hundred and eight accessions of oats along with five standard varieties were under taken to evaluate and identify suitable genotypes for green fodder yield for Pakistan.

MATERIALS AND METHODS

One hundred and eight accessions of oats including five check varieties collected from National Fodder Research Programme and NARC, Islamabad were sown in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan. The experiment was laid out in an Augmented design. Four rows of each accession were sown in a plot of $1.2 \times 5.0\ m^2$ keeping row to row distance of 30 cm and plant to plant 15 cm. Recommended cultural and agronomic practices were applied to all the genotypes. Fertilizers at the rate of 75-50-00 NPK Kg ha-1 were applied, respectively. Whole phosphorus and half nitrogen were applied at the time of seed bed preparation in the form of di-ammonium phosphate (DAP) and urea, respectively. Whereas, remaining half of nitrogen was applied after 25 days with first irrigation [**16**]. When the heads started to emerge the data were recorded on days taken to 50% flowering, days taken to 50% maturity, plant height (cm), internodal length (cm), number of leaves per main culm, leaf area (cm^2), number of tillers /meter row, green fodder yield (tons/ha) and dry mater yield (tons/ha) from ten randomly selected plants of each accession following standard procedures. The data recorded were analyzed statistically following the augumented technique [**12**]. Genotypic and phenotypic correlations were computed according to [**17**] and broad sense heritability was estimated according to **[7]**.

RESULTS AND DISCUSSION

Analysis of variance of one hundred and eight accessions of oats revealed highly significant differences ($p<0.01$) for plant height, internodal length, number of leaves per plant and leaf area **(Table 1)**. Mean values and range of various traits presented in **Table 2** also indicated variability for number of tillers, days to 50% flowering, days to 50% maturity, green fodder yield and dry matter yield in accessions of oats. Check varieties varied significantly for all the traits recorded **(Table 2)**. Coefficient of variation for plant height for accessions was 0.73% and for check varieties it was 1.26%. Mean plant height of 108 accessions of oat was 120.4cm and range was 66.2-175.3cm. Similarly mean plant height for check varieties was 128.6cm and range was 107.7-170.1cm **(Table 3)**. **[18]** reported significant difference for plant height (102.78-126.61cm) in oat genotypes which agreed with the present findings. The present findings were in line with those of who reported that accessions were more in plant height as compared to check varieties **[9]**.

Coefficient of variation of accessions of oats for internodal length was 4.49% and for check varieties 6.68%. Mean internodal length of accessions of oat was 14.2 (cm). Range of oat accessions for internodal length was 8.7-22.5 (cm). Mean internodal length for check varieties was 16.2cm and range was 11.3 - 19.7cm **(Table 3)**. Coefficient of variation of various accessions of oats for number of leaves was 4.30% and for check varieties coefficient of variation was 5.12%. Mean number of leaves of 108 accessions of oat was 6 and range was 4.0 to 8.3. Similarly mean value for check varieties was observed 6.2 and range was 5-7 **(Table 3)**. Coefficient of variation for leaf area was 1.04% of various accessions of oats and for check varieties coefficient of variation was 1.20% **[14, 19]**. Mean value for leaf area of 108 accessions of oats was 66.5 (cm^2). Range of oat accessions was 18.4-115.6 (cm^2). Mean value of leaf area for check varieties was 65.8 and range was 40.2-87.1cm^2 **(Table 3)**. **[18]** found significant differences for leaf area (52.32-91.30 cm^2) which agreed much with present study **[20, 14]**.

Coefficient of variation for number of tillers for check varieties was 1.52%. Mean number of tillers/meter row of 108 accessions of oat were 138.4. Range for number of tillers/meter row of oat accessions was 27 to 311. Mean number of tillers/meter row for check varieties were 157.6 and range was 122 to 193 **(Table 3)**. **[18]** found significant differences for number of tillers (85-114.33) which agreed with present study. Coefficient of variation for days to 50% flowering for check varieties was 0.39%. Mean value for days to 50% flowering of various accessions of oat was 138.7 and range was 105 to157 **[21, 10]**. Similarly mean value of days to 50% flowering for check varieties was 136 and range was 126-146 **(Table 3)**. **[21]** found moderate to high amount of variability for days to flowering in different oat genotypes. Coefficient of variation for days to 50% maturity for check varieties was 0.13%. Mean days to 50% maturity of 108 accessions of oat was 172.6 and range of various oat accessions was 131-190. Mean value for check varieties was observed 161.8 and range was 131 to 172 **(Table 3)**. Coefficient of variation for green fodder yield for check varieties was 1.26% **[22, 23].** Mean green fodder yield of various accessions of oat was 28.24 (tons/ha) and range observed was 5.0 to 57.5 (tons/ha). Mean green fodder yield of check varieties was39 t/ha and range was 25-57.5 t/ha **(Table 3)**. **[23]** reported highest fodder production of 47.12 (t/ha) and 38.1(t/ha) in different oat varieties. But present findings were quite higher. It may be due to genetic and environmental factors. Coefficient of variation for dry matter yield for check varieties was 0.63%. Mean value for dry matter yield of accessions of oat was 5.8 (tons/ha) and range of oat accessions was 1.3-17.3 (tons/ha) **[20, 4]**. Similarly mean dry matter yield for check varieties was 8.02 and range observed was 3.1-17.3 t/ha **(Table 3)**. The results were in line with **[14, 19, 23, 24]** they reported variation for dry matter yield in oat genotypes. It is persuaded from **Table 5** that the highest heritability estimates were found for almost all traits [**13, 25, 10, 4]**. The higher estimate of heritability indicated the selection of higher fodder yielding oat genotypes may be helpful for the improvement of fodder yield.

CORRELATION

A positive and significant correlation was observed at genotypic level with days to 50% flowering, days to 50% maturity, number of leaves, internodal length, leaf area and dry matter yield. At phenotypic level positive and highly significant correlation was obtained with days to 50% flowering, number of leaves, leaf area and dry matter yield **(Table 4)**. A negative relationship of plant height with fodder yield was recorded, which was in line with present study **[14, 19]**. Plant height, number of tillers/ meter row and green fodder yield were positively and significantly correlated with internodal length at genotypic level. At phenotypic level positive and highly significant correlation was obtained with number of tillers but negative and highly significant correlation was with days to 50% flowering, days to 50% maturity and number of leaves **(Table 4) [16, 11]**.

The results presented in the (Table 4) revealed a positive and significant relationship at genotypic level with days to 50% flowering, days to 50% maturity, plant height and leaf area. At phenotypic level positive and highly significant relationship was observed with days to 50% flowering, days to 50% maturity and plant height while negative and significant correlation was with internodal length and number of tillers. Plant height, number of tillers, number of leaves and leaf area were non-significant correlated with fodder yield **[14, 15]**. The results presented in the **(Table 4)** revealed a positive and significant relationship at genotypic level with days to 50% flowering, days to 50% maturity, plant height, number of leaves per plant, dry matter yield and green fodder yield. Positive and highly significant correlation was observed at phenotypic level with days to 50% flowering, days to 50% maturity, plant height, dry matter yield and green fodder yield but negative and significant relationship was estimated with number of tillers **[26, 19]**.

A positive and significant correlation was observed at genotypic level with internodal length, dry matter yield and green fodder yield while others showed no correlation for this character. At phenotypic level positive and significant correlation was observed with internodal length, dry matter yield and green fodder yield but negative and highly significant correlation was with days to 50% flowering, maturity, number of leaves and leaf area **(Table 4) [13, 25, 9, 10, 4]**. A positive and significant correlation was observed at genotypic level with days to 50% flowering, plant height, number of leaves and leaf area. Positive and highly significant correlation at phenotypic level was observed with number of leaves and leaf area but negative and highly significant correlation was observed with internodal length and number of tillers/ meter row **(Table 4) [5, 3]**. The results presented in the **(Table 4)** revealed a positive and significant relationship at genotypic level with days to 50% maturity, plant height, leaf area, number of leaves and dry matter yield. At phenotypic level positive and highly significant correlation was observed with plant height, number of leaves and leaf area but negative and highly significant correlation was obtained with internodal length, number of tillers and green fodder yield **[21, 4]**.

A positive and significant correlation of green fodder yield at genotypic level was observed with leaf area, number of tillers/meter row and internodal length. At phenotypic level positive and significant correlation was observed with leaf area, number of tillers and dry matter yield but negative and highly significant correlation was observed with days to 50% flowering **(Table 4)**. The green fodder yield had a positive correlation with number of leaves **[16, 13, 15, 9, 4]**. Positive and significant correlation at genotypic level was observed for this trait with days to 50% flowering, plant height, number of leaves, leaf area, number of tillers/ meter row and green fodder yield. At phenotypic level positive and significant correlation was observed with plant height, leaf area, number of tillers and green fodder yield **(Table 4) [22]**. Dry matter yield was positively correlated with green fodder yield and number of tillers which agreed with present investigations **[16, 2, 13]**.

Table 1: Mean Square Values from Analysis of Variance of the Various Accessions of Oats for Fodder Yield Components

SOV	DF	PH	IL	NL	LA
Accessions	107	3609.51**	90.87**	5.63**	3918.78**
Error	972	83.92	3.97	0.27	364.58

**** = significant at 0.01 probability level, SOV = sources of variation, DF = degrees of freedom, PH = plant height, IL = internodal length, NL = number of leaves, LA = leaf area**

Table 2: Mean Square Values from Analysis of Variance of the Check Varieties for Various Fodder Yield Components

SOV	DF	PH	IL	NL	LA	NT	DTF	DTM	GFY	DMY
Blocks	3	5.0	4.18	0.06	3.00	22.30	0.32	0.05	0.23	0.002
Checks	4	4526.0**	37.24**	2.175**	2015.40**	2884.40**	229.75**	159.05**	945.66**	19.01**
Error	12	2.80	0.92	0.11	0.90	5.30	0.32	0.050	0.18	0.002

**** = significant at 0.01 probability level, SOV = sources of variation, DF = degrees of freedom, DTF = days taken to 50% flowering, DTM = days taken to 50% maturity, PH = plant height, NT = number of tillers/meter row, IL = internodal length, NL = number of leaves, LA = leaf area, GFY = green fodder yield, DMY = dry matter yield**

Table 3: Variability of Accessions and Check Varieties of Oat for Various Fodder Components

Characters	108 accessions		Check varieties	
	Mean value	Range	Mean value	Range
PH	120.4	66.2-175.3	128.6	107.7-170.1
IL	14.2	8.7-22.5	16.2	11.3-19.7
NL	6	4-8	6.2	5-7
LA	66.5	18.4-115.6	65.8	40.2-87.1
NT	138.4	27-311	157.6	122-193
DTF	138.7	105-157	136	126-146
DTM	172.6	131-190	161.8	131-172
GFY	28.24	5.0-57.5	39.0	25.0-57.5
DMY	5.8	1.3-17.3	8.02	3.1-17.3

DTF = days taken to 50% flowering, DTM = days taken to 50% maturity, PH = plant height, NT = number of tillers/meter row, IL = internodal length, NL = number of leaves, LA = leaf area, GFY = green fodder yield, DMY = dry matter yield

Table 4: Genotypic (upper level) and Phenotypic (lower level) Correlation Coefficients Among Morphological Traits in Oat Accessions

Variables	DTM	PH	NL	IL	LA	NT	DMY	GFY
DTF	0.738*	0.284*	0.348*	-0.634	0.536*	-0.382	0.172*	-0.343
	0.737	0.284**	0.344**	-0.632**	0.535**	-0.382**	0.172	-0.343**
DTM		0.075*	0.410*	-0.645	0.346*	-0.410	-0.058	-0.202
		0.075	0.406**	-0.641**	0.346**	-0.409**	-0.057	-0.202
PH			0.439*	0.117*	0.348*	-0.127	0.211*	-0.065
			0.434**	0.117	0.348**	-0.127	0.211*	-0.065
NL				-0.356	0.118*	-0.563	-0.062	0.029
				-0.348**	0.177	-0.555**	-0.061	0.029
IL					-0.090	0.268*	-0.203	0.109*
					-0.089	0.267**	-0.202	0.109
LA						-0.328	0.474*	0.238*
						-0.328**	0.474**	0.238*
NT							0.242*	0.246*
							0.242*	0.246*
DMY								0.549*
								0.549**

***= significant (p<0.05), **= highly significant (p<0.01), DTF= days to 50% flowering, DTM= days to 50% maturity. IL= Internodal length, NT= number of tillers, LA= leaf area, DMY= dry matter yield, PH= plant height, GFY= green fodder yield, NL= number of leaves**

Table 5: Genetic Parameters for Different Characters in Oat (*Avena sativa* L)

Characters	6^2_g	6^2_p	GCV	PCV	$h^2_{(B.S)}$
Days to 50% flowering	96.93	96.99	0.680	0.681	0.999
Days to 50% maturity	69.73	69.82	0.396	0.396	0.998
Plant height	445.72	445.95	3.382	3.383	0.999
No. of leaves	0.86	0.88	0.133	0.136	0.978
Internodal length	10.57	10.68	0.736	0.743	0.990
Leaf area	816.03	816.19	10.218	10.220	0.999
No. of tillers	3093.82	3095.53	20.533	20.544	0.999
Dry matter yield	10.52	10.52	1.394	1.394	0.999
Green fodder yield	104.51	104.54	3.138	3.139	0.999

6^2_{g} = Genotypic variance, 6^2_{p} = Phenotypic variance, GCV = Genotypic coefficient of variance, PCV = Phenotypic coefficient of variance, h^2 = Heritability (Broad sense)

CONCLUSION

Above results indicated that a large amount of variation within accessions existed and such variation is helpful for plant breeder to exploit for the improvement of oat crop plants. Relationship of traits may be resulted from pleiotropic effects of genes, existence of two genes on the same chromosome, chromosomal segmental affiliation or due to the environmental influences. However, correlation analysis figures out the intensity of relationship between the two traits. Heritability estimates are of great importance to plant breeder primarily as a measure of the value of selection for particular characters in various types of progenies and a special tool for a more accurate separation of variability due to inheritance.

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