I.J.S.N., VOL.6 (4) 2015: 590-595 ISSN 2229 – 6441

INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

STABILITY ANALYSIS FOR FORGE QUALITY TRAITS IN OATS (*AVENA SATIVA* L.) OVER ENVIRONMENTS

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ABSTRACT
Ten genotypes of oats were planted at three diverse environments were to assess genotype environment interaction and determine stable oat (*Avena sativa* L.) cultivar in Kashmir division for forage quality attributes using randomized block design during 2010 to 2011. Stability analysis for forage quality conducted to check the response to Genotype x environment interactions. The mean squares due to G x E (linear) were significant depicting genetic differences among genotypes for linear response to varying environments, while mean squares due to pooled deviations were highly significant, reflecting considerable differences among genotypes for non-linear response. Out of ten genotypes for physiological, forage quality and forage yield, only three genotypes i.e., SABZAAR, SKO-212 and SKO-213 with non-significant deviation from regression, unit regression coefficient and being superior in yield appeared as a prominent lines, to be the most stable for yield performance under varying environments. SKO-212 showed non-significant deviation from regression and their regression coefficient values were close to unity classified were desirable for all physiological, forge quality and highest forage yield across the environments. The other test cultivars were sensitive to production-limiting factors, their wider adaptability, stability and general performance to the fluctuating growing conditions within and across environments being lowered.

KEYWORDS: G x E interaction, Stability analysis, Forage yield, Oats.

INTRODUCTION
Oats occupies a prominent place among *rabi* fodders in India. It is preferred feed of all animals and its straw is soft and grain is also valuable feed for horses, dairy cows, poultry and young breeding animals. The demand of meat, beef, milk, butter and their by products is increasing due to rapidly growing human population in India. Forages of varying quality support different levels of production. Forage is important in the sense of providing fiber to ruminants. Inadequate levels of dietary fiber are associated with low milk fat, rumen acidosis and dietary inefficiency. Forages provide rumen buffering and improve the fermentation efficiency of starchy grains. Forage also provides effective fiber in dairy rations where 75% of ration neutral detergent fiber should come from coarse forages. Selection of forage for a dairy ration is crucial in production terms as well as economic sustainability. In this context there is a need to nutritionally evaluate newly developed oat cultivars for using as dairy forage in comparison to established forages such as barley. Forage in dairy ration is important in the context of providing adequate amount of effective fiber to cow (Mertens, 1997). Barley silage which is the commonly used forage source for dairy rations in most parts of the world, can be replaced by an alternative such as a comparable oat silage, it has been shown that oat produces more forage dry matter yield than most of the other cerealcrops (Carr *et al*., 2001). Forage quality means the ability and the extent to which forage has the potential to produce a desired animal response. Thus the quality reveals the level of nutrient (chemical) composition, palatability and intake, digestibility, anti-nutritional factors and animal production performance. Many factors influence forage quality. Some of them are forage cultivar, stage of maturity at harvest and storage method. Secondarily environmental factors such as soil type and fertility, day length, temperature during plant growth are also important (Ball, 2000). As ruminants are capable of digesting forage carbohydrates for the primary source of energy, carbohydrate characteristics have long been of interest as major factors in determining forage quality. Nutritive value implies not only the proportion of nutrients present in the plant, but also the intake and the digestibility by the animals (Ahmad *et al*., 2014a). Van Soest (1986) reported that forage intake is dependent upon the cell wall content, while forage digestibility is dependent on the cell wall (neutral detergent fiber) content and its availability determined by lignifications and other factors. The plant cells are composed of two major fractions; cell walls and cellular contents. The plant cell wall is the principal structure surrounding the protoplast and cell membrane and varies in digestibility. NDF has proven of value providing a robust measure of the cell wall content of forages and enables to distinguish cellular differences between forage and concentrates (Mertens, 1997). The NDF represents the insoluble matrix of

the plant cell wall, substances covalently linked or so intimately associated through hydrogen bonding, crystalline, or other intra-molecular association that are resistant to solutions within the range of physiological concentrations in rumen fluid. NDF is a valuable analysis that rank all feed stuffs in a continuum from feeds containing no fiber, low fiber concentrates, to high fiber straws and cellulose. Although NDF recovers the indigestible components, unlike ADF (which does not include hemicelluloses) or crude fiber (lignin and hemicellulose), its correlation with digestibility for ruminants is inferior to ADF. Acid detergent fiber (ADF) mainly consists of the insoluble hemicellulose and the insoluble lignin and cellulose. ADF is widely used as a quick method for estimating fiber in feeds, often substituting for crude fiber as a part of a proximate analysis. ADF is relatively low in digestibility and hence ADF content can be used to predict the energy content of forage (Beauchemin *et al*., 1996). According to these authors a robust attention and appreciation for the analytical variability and the limitations of predicting energy content from ADF is needed to interpret feed analysis reports in terms of animal performance. Generally a prediction of DM intake from NDF depends on number of factors, but NDF content of forage should be used in diet formulation to ensure adequate fiber. To maximize milk yield and milk fat content, both dietary NDF intake (as a percentage of body weight) and energy intake must be maximized. Diets for high producing dairy cows should be formulated to obtain the highest possible concentration of NDF from forage in the diet, while meeting the requirement for energy density. This can only be achieved by maximizing forage quality. According to NRC (2001) a minimum of 15% forage NDF should be included in dairy diet and dietary non fiber carbohydrate should not exceed 44%. Oats genotypes that are low in neutral detergent fibre (NDF) and acid detergent fibre (ADF) have good forage quality because low NDF is associated with high forage intake and low ADF is associated with high digestibility. Protein content is an important feed factor *per se* with high quality feed having high protein content. The total mineral content (ash) is 3 to 12% dry matter. The minerals typically determined are calcium and phosphorus (Ahmad et al., 2014b). In J&K State livestock population is 7.8 million so the fodder production is not sufficient enough to meet the requirements of a burgeoning livestock population (Anonymous, 2009). The farmers face fodder deficiency in winter when they have only dry stalks of summer cereal fodders or dry summer grasses. In order to increase in productivity *per* unit area there is need to develop varieties having higher forage yield potential and quality. Inadequate supply of quality feed and fodder is the primary cause of lower productivity of milch animals in India (Patel *et al*., 2011). In Jammu and Kashmir, fodder requirement is about 4.31 against the availability of 3.26 million tones, there by having deficient of 1.05 million tones on dry matter basis (Anonymous, 2008). Kashmir valley experienced a long lean period of winter, resulting to meet the need of animal products and to maintain good health and potential of livestock in terms of milk, meat and wool, there is a great importance of fodder cultivation to compensate the fodder scarcity during lean period. The present production is not proportionate with the demand. So, oats deserves a deep deliberation for improvement. It should be highly pragmatic by the fact that, sixty corers animals will need 1097 and 1170 million tonnes of green fodder, respectively. Deficiency of green fodder will be about 64.9% and for dry fodders it may go to up to 24.9% in 2025 A.D (Government of India Planning Commission, 2001). It should pave the way for bringing about a kind of plant type, which could enhance its quality and productivity without sacrificing the consumer needs. So, there is an urgent need of exploiting new research technologies to boost forage yield in terms of higher yield of green fodder and dry matter per unit are. The competition for utilization of land for food grains and fodder necessitates intensified efforts towards more efficient forage production. The forage oat varieties having higher productivity, better quality and tolerance to abiotic stress is the need of the hour in bridging the gap between demand and supply of green fodder.

The phenotypic performance of a genotype may not be the same under diverse agro climatic conditions. This variation is due to G x E interactions, which reduces the stability of a genotype under different environments (Ashraf *et al.*, 2001). Many models have been developed to measure the stability of various parameters and partitioning of variation due to G x E interactions. The most widely used model (Eberhart & Russell, 1966) was followed to interpret the stability statistics in different crops. The yielding ability of a variety is the result of its interaction with the prevailing environment. Environmental factors such as soil characteristics and types, moisture, sowing time, fertility, temperature and day length vary over the years and locations (Ahmad *et al.,* 2014c). There is strong influence of environmental factors during various stages of crop growth (Bull *et al.*, 1992), thus genotypes differ widely in their response to environments. Many research workers are of the view that average high yield should not be the only criteria for genotype superiority unless its superiority in performance is confirmed over different types of environmental conditions (Qari *et al.*, 1990). Therefore, in the present investigation an attempt has been made to evaluate oat genotypes for forage quality and yield and its component characters under different environments to identify genotypes with suitable performance in variable environments.

MATERIAL & METHODS

The basic material for the present study consisted of ten diverse genotypes of Oats (*Avena sativa* L.) *viz*: SKO-204, SKO-205, SABZAAR, SKO-207, SKO-208, SKO-209, SKO-210, SKO-211, SKO-212, and SKO-213 (Table 1) selected from the germplasm collection maintained at Division of Plant Breeding and Genetics, SKUAST-K, Shalimar were evaluated at three locations viz., Experimental Farm of the Division of Plant Breeding and Genetics, SKUAST-K, Shalimar, Mountain Research Centre for Field Crops, Khudwani Anantnag and FOA, Wadura.

During rabi 2011-2012 in a randomized block design with three replications at each location and each treatment was sown in 2 rows each of 4 meter length. Row to row and plant to plant spacing was maintained at 30 and 10 cm. The observations were recorded on six forage quality and forage yield. The leaf area index (LAI) of randomly selected leaves from each plot was measured by canopy analyzer (Acuapar LP-80) at the beginning of anthesis. The chlorophyll content was measured in field on fully expanded flag leaves at anthesis with the help of chlorophyll meter (SPAD-502, Konica Minolta Sensing). The average reading was taken and conversion equations used to convert relative SPAD-502 values to leaf chlorophyll concentration (g m−2) (Gandía *et al.,* 2007). The forage quality was determined after the samples were dried and crushed to a fine powder. The forage quality parameters for which these genotypes were studied included, crude protein content (Jackson, 1973), neutral detergent fibre (Goering and Vansoest, 1970), acid detergent fibre (Goering and Vansoest, 1970), ash content (AOAC, 1984) and crude fibre (Maynard, 1970). Data was subjected to analysis of variance to find significant differences among genotypes for the recorded data. After obtaining the significant differences, Data were subjected to stability analysis according to Eberhart and Russel (1966).

TABLE 1: Oats genotypes used in the study with their accession number

S. No.	Genotype	EC number/ Place of collection
1.	SKO-204	EC-529089
2.	SKO-205	EC-529090
3.	SKO-207	EC-529092
4.	SKO-208	EC-529093
5.	SKO-209	EC-529094
6.	SKO-210	EC-529095
7.	SKO-211	EC-529096
8.	SKO-212	EC-529097
9.	SKO-213	EC-529098
10.	Sabzaar	Released variety (SKUAST-Kashmir)

RESULT & DISCUSSION

The combine analysis of variance (Table 2) revealed that there were significant differences among environments and genotypes for quality and yielding traits indicating the presence of variability in genotypes as well as diversity of growing conditions at different locations. The G x E interaction was highly significant reflecting the differential response of genotypes in various environments (Ahmad *et al*., 2014c). By partitioning G x E interaction into linear and nonlinear (pooled deviation) components, it is noted that differences between environments (environment linear) were highly significant, which indicated the genetic control of genotypic response to environments ((Nehvi *et al.*, 2007). The G x E interactions, were however of non-linear type, because G x E (linear) significant, reflecting there is a genetic differences among genotypes for their response to varying environments. While pooled deviations were highly significant against pooled error (Table III) showing that the differences in stability were due to deviation from linear regression only (Ashraf *et al.*, 2001). Thus, both linear (predictable) and non-linear (un-predictable) components significantly contributed to genotype x environment interactions observed for all the characters. This suggested that predictable as well as un-predictable components were involved in differential response of stability. Similar results were reported by (Ackura and Ceri, 2011). Baker (1988) regarded deviation from regression (Sd2) to be the most appropriate criteria for measuring phenotypic stability in an agronomic sense, because this parameters measure the predictability of genotypic reaction to environment with these parameters, high and desirable per se performance of a variety over environment is also a positive point to rate the variety as a better and highly stable genotype. The stability parameters for all cultivars are given in (Table 3). Eberhart and Russell (1966) emphasized the need of considering both linear (bi) and non-linear (S^2di) components of genotype-environment interactions in judging the stability of a genotype. A wide adaptability genotype was defined as one with bi =1 and high stability as one with S^2di=0. The stability parameters for physiological traits viz, chlorophyll content and leaf area index (table 2). In this study values for the regression coefficient (bi) ranges from 1.001 (SKO-208) to 10.004 (SKO-210) for chlorophyll content, 1.005 (SKO-213) to 4.442 (SKO-210) for leaf area index. The regression coefficient (bi) of genotypes *viz*, SABZAAR, SKO-208 and SKO-209 for physiological traits was non-significant and almost approaching unity (bi =1) and it had the lowest and non-significant deviation from regression and was most suitable for over all the locations. Zhao *et al.* (2008) observed that chlorophyll content has significant but positive relationship with grain yield. Xie *et al.* (2011) reported that grain yield originated mostly from the photosynthesis and LAI of leaves after heading. Grain yield was significantly and positively correlated with leaf area index and chlorophyll content. These traits were used as selection criteria to improve oat cultivars with higher grain and forage yield (Ahmad *et al.*, 2013d).

TABLE 2: Analysis of variance for stability for forage quality and forage yield Oats (*Avena sativa* L.)

Source of variation	Df	Mean square							
		Chlorophyll content	LAI	Crude protein content (%)	NDF (%)	ADF (%)	Crude fibre (%)	Ash Content (%)	Green fodder yield
Genotype (G)	9	75.986**	21.090**	7.443**	3.337**	2.664**	9.701**	11.232**	11.706**
Environment (E)	2	390.866**	33.112**	4.078**	6.908**	3.960**	9.004**	12.001**	1.110*
G x E	18	42.121**	4.345**	2.114**	1.778**	0.998**	2.303**	6.220**	210.647
Pooled error	54	0.0784	0.0532	0.006	0.434	0.231	0.523	0.907**	0.015
Environment + (G x E)	20	57.665**	21.578**	10.423**	11.098**	8.897**	14.337**	18.070**	0.694*
E (Linear)	1	33.535**	4.223**	2.789**	5.448**	3.006**	7.317**	9.910**	2.220*
G X E (Linear)	9	82.435**	5.246**	4.442**	12.007**	4.449**	6.002**	7.668**	1.024*
Pooled Deviation	10	5.786**	0.673**	0.805**	0.671**	0.521**	0.980**	0.988**	0.244**

*: Significant at 5% level; **: Significant at 1% level

LAI= Leaf area index, NDF= Neutral detergent fibre, ADF= Acid detergent fibre

TABLE 3: Stability parameters for forage quality traits and yield and its attributing traits in Oats

Genotype	Chorophyll content (gm^{-2})			LAI			Crude protein content (%)			NDF%		
	Mean	Bi	S^2 di	Mean	Bi	S^2 di	Mean	Bi	S^2 di	Mean	Bi	S^2 di
SKO-204	0.454	2.342	0.980*	3.18	1.976	2.006**	10.32	2.887	1.331**	53.70	6.606	3.20**
SKO-205	0.534	0.554	2.041**	5.27	3.321	1.11**	6.82	4.002	3.33**	55.40	2.111	4.001*
SABZAAR	0.508	1.001	3.007**	2.93	1.221	0.973	6.47	1.007	0.009	58.40	1.231	0.054
SKO-207	0.526	1.987	4.223**	3.98	2.332	2.055**	10.15	2.331	1.56**	56.50	1.030	2.00**
SKO-208	0.537	1.001	0.096	5.31	1.022	0.045	10.67	1.001	0.002	59.70	1.097	3.07**
SKO-209	0.501	1.006	3.556**	3.37	-4.643	2.22**	10.50	1.998	0.99*	55.90	2.222	1.061*
SKO-210	0.508	10.004	2.131**	4.13	4.442	1.774*	8.75	5.002	2.22*	58.80	5.552	2.243**
SKO-211	0.536	0.030	0.905	5.90	0.086	-00.077	8.92	0.988	0.89*	54.70	0.111	1.003*
SKO-212	0.536	1.031	0.010	4.12	1.034	0.008	10.13	1.002	0.012	54.10	1.002	0.096
SKO-213	0.505	1.089	0.241	3.94	1.005	-0.070	10.52	1.006	0.071	55.80	1.002	0.003
Population mean	0.515			3.85			9.31			56.34		
SE ±	0.007			0.128			0.274			0.366		

Genotype	ADF%			Crude fibre (%)			Ash Content (%)			Green fodder yield		
	Mean	Bi	S^2 di	Mean	Bi	S^2 di	Mean	Bi	S^2 di	Mean	bi	S^2 di
SKO-204	33.90	8.00	3.444**	27.00	0.090	0.987**	6.50	2.556	1.908**	105.7	0.37	0.09**
SKO-205	39.40	2.13	3.999**	26.30	1.907	-0.060	6.70	3.444	1.661*	112.11	1.91	-0.01
SABZAAR	39.60	1.44	0.982	26.50	1.080	0.012	6.60	1.001	0.040	85.13	1.02	0.007
SKO-207	32.20	1.224	1.037*	25.20	-0.056	0.999**	6.80	4.908	1.222*	107.13	-0.01	0.07**
SKO-208	32.80	1.005	3.002**	25.40	2.331	3.095**	6.40	1.091	1.002*	106.1	0.61	0.17**
SKO-209	33.80	1.779	2.332**	27.70	-1.761	0.552*	6.90	1.004	0.004	105.1	1.28	0.59**
SKO-210	38.90	4.553	1.771**	26.40	3.464	1.331*	6.70	3.566	2.00**	111.0	2.16	0.88**
SKO-211	38.00	0.708	0,987	29.40	0.077	0.008	6.60	0.303	0..988	111.0	0.05	0.062
SKO-212	34.20	1.119	0.019	24.40	1.080	0.070	6.20	1.020	0.003	112.8	1.00	0.005
SKO-213	31.80	1.007	0.004	22.80	2.001	0.996	6.40	1.088	0.009	110.7	1.06	0.026
Population mean	33.05			25.91				6.49		106.6		
SE ±	1.414			0.322				0.046		0.474		

(bi) Regression coefficient, (S^2di) deviation from regression (Eberhart and Russell,1966).

*: Significant at 5% level; **: Significant at 1% level

The values for the regression coefficient (bi) of forage quality and yield ranges from 1.001 (SKO-208) to 5.002 (SKO-210) crude protein content %, 1.002 (SKO-212) to 6.606 (SKO-204) NDF%, 1.005 (SKO-208) to 8.008 (SKO-204) ADF%, -1.761 (SKO-209) to 3.464 (SKO210) Crude fibre %, 1.001 (SABZAAR) to 4.908 (SKO-207) for ash content % and 1.001 (SKO-213) to 2,167 (SKO-210) grain yield plant^{-1} (g). The regression coefficient (bi) of genotypes viz, SABZAAR, SKO-212 and SKO-213 for forage quality crude protein content %, NDF%, ADF%, Crude fibre %, ash content % and grain yield plant^{-1} (g) was non-significant and almost approaching unity (bi =1) and it had the lowest and non-significant deviation from regression and was most suitable for over all the locations. The regression coefficient of genotypes for physiological trats viz, chlorophyll content and leaf area index SKO-112 was non-significant and almost approaching unity (bi =1) and it had the lowest and non-significant deviation from regression and was most suitable for over all the locations. Physiological traits positively correlated with grain yield and green forage yield it will consider during breeding programme for development of high yielding varieties both for forage and grain yield.

CONCLUSION

The cultivar "SKO-212" and SKO-213 found to be most stable cultivar for forage quality and green forage yield over all the locations. Hence, this cultivar may be recommended for cultivation in different environment. The cultivar viz SKO-204, SKO-205, SKO-207, SKO-209 and SKO-210 gave below average performance beside devotion from regression was significant since the performance od these cultivars seems to be unpredictable. The cultivar SKO-2011 have a regression coefficient lees than unity and forage yield below average indicating that it offers greater resistance to environmental changes and is specially adopted to poor environments. SABZAAR is the only cultivar that is the most stable performance for all diverse environments and it had the lowest and non-significant deviation from regression for all forage quality traits and forage yield and was most suitable for over all the locations. Only the forge of this cultivar is below average forage yield we improve this yield through hybridization programme or through molecular or biotechnological approaches are best candidates for evaluating this performance under marginal environments through participatory varietal selection.

ACKNOWLEDGEMENT

The authors are highly thankful to the Punjab Agriculture University for allowing me to carry out the forage quality analysis such as NDF, ADF, CRUDE FIBRE during my research programme.

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