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Research Article

Stability analysis for physiological traits, grain yield and its attributing parameters in oats (*Avena sativa* L.) in the Kashmir valley

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Abstract
Eleven genotypes of oats were planted at six diverse environments to assess genotype environment interaction and determine stable oat (*Avena sativa* L.) cultivar in Kashmir division for grain yield using randomized block design during 2014 to 2015. There was considerable variation in grain yield and physiological traits within and across environments. Stability analysis for grain yield was 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. Mean squares due to pooled deviations were highly significant, reflecting considerable differences among genotypes for non-linear response. Out of eleven genotypes, only three oats lines i.e., SKO-98, SKO-166 and Sabzaar, showed non-significant deviation from regression and their regression coefficient values were close to unity and desirable for grain yield across the environments. The cultivar, "SKO-98" with respective regression coefficient value of 1.018, the smallest deviations from regressions (S^2di) value (0.025) and the above average grain yield could be considered the most widely adapted cultivar.

Key words
G x E interaction, stability analysis, grain yield, oats

Introduction

Oat (*Avena sativa* L.) is a cereal crop of global importance used for food, feed, and forage (Tinker *et al*., 2009). Differing from other cereal grains such as wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.), oat is a multipurpose cereal crop grown worldwide for human food and animal feed (Dubey *et al*., 2014). Quality Oats are increasingly in demand and in many places a highly-profitable market grain. The high margin is due to very small production costs and the numerous choice of following crop. Close crop rotations with high winter grain portions have become increasingly under pressure in recent years. Oats are viewed by consumers as one of the wholesome, healthiest; natural food with the result there is rising global food demand for oats. Among cereals, the highest amounts of β-glucans are found in barley and oat grains (Ahmad and Zaffar, 2014). 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 yield (Ahmad and Zaffar, 2014). Quality oats are imported by India (about 5 to 6 tons from Australia, Russia and Canada) for human consumption involved a huge amount of money, instead of this if we develop a high yielding quality oat variety suited to temperate conditions of Kashmir valley India become self-sufficient and full fill the demand of quality oats for human consumption as well as for increasing livestock population. Therefore, there is an urgent need to develop stable cultivar under different environmental conditions of Kashmir valley in India.

Farmers and scientists want successful new oat genotypes that show high performance for yield and other essential agronomic traits. Their superiority should be reliable over a wide range of environmental conditions but also over years. The basic cause of differences between genotypes in their yield stability is the occurrence of genotype-environment interactions (GEI). The real estimate of a genotype gets biased if G x E interaction is present and this results when a crop is grown in a single environment. The multi environmental testing allows reducing this basis. The knowledge about the extent of fluctuations of yield and yield attributes over environments is very important to identify genotypes which are widely adapted. Yield is a quantitatively inherited character and there is considerable interaction between genotypes and environments. Some of the crop varieties are widely adapted, while as others are not so, multi-location trials play an important role in plant breeding and agronomic research. 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. 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.*, 1999). Therefore, in the present investigation an attempt has been made to evaluate oat genotypes for grain yield and its component characters under different environments to identify genotypes with suitable performance in variable environments.

Materials and methods

The experiment was conducted with 12 genotypes of oats *viz*.,SKO-20 (Shalimar fodder oats – 1), SKO-90 (Shalimar fodder oats – 2), SKO-96 (Shalimar fodder oats – 3), SKO-98 (Shalimar fodder oats – 4), SKO-117, SKO-148, SKO-160, SKO-166, and SKO-167, SKO-176, Sabzaar and Kent, during *rabi* 2013-14 in Districts of Ganderbal, Shopian, Srinager, Bandipora and Pulwama of Kashmir valley. For laying out of trials at farmers field as well as research stations and KVK's including Experimental Farm of Division of Genetics and Plant Breeding, SKUAST-Kashmir, Shalimar district Srinagar; KrishiVigyan Kendra, Malangpora, Pulwama district Pulwama; Mountain Livestock Research Institute (MLRI), Manasbal district Bandipora. In the present investigation an attempt has been made to evaluate oat genotypes for higher grain yield over the environments. Each genotype was planted in a randomized complete block design with three replications and trials were represented by five rows of five meter length with row to row and plant to plant spacing of 25 and 15 cm respectively. Observations were recorded on ten randomly selected plants from each genotype in all the three replications. Leaf area index (LAI) measured by canopy analyzer (Acuapar LP-80) at the beginning of anthesis. The chlorophyll content measured in field on fully expanded flag leaves at anthesis with the help of chlorophyll meter (SPAD-502, Konica Minolta Sensing), spiklets panicle^{-1}, seeds panicle^{-1}, 1000 seed weight (g) and grain yield plant $^{-1}$are recorded. The data were statistically analyzed and the genotypes were assessed for their stability of performance across environments following the method described by Eberhart and Russell (1966).

Results and discussion

The stability analysis (Table 1) indicated the presence of significant G x E interaction for all the characters under study. Higher magnitude of mean squares due to environments indicates considerable difference between environments for all the characters suggesting large difference between environments along with greater part of genotypic response i.e., the environments created by locations were justified and had linear effects (Ahmad *et al.*, 2014). By partitioning G x E interaction into linear and nonlinear (pooled deviation) components, differences between environments (environment linear) were highly significant, which indicated the genetic control of genotypic response to environments.

The portioning of mean squares (environments + genotype x environments) (Table 1) showed that environments (linear) differed significantly and were quite diverse with respect to their effects on the performance of genotypes for physiological traits, grain yield and majority of yield components. The significance of mean squares due to genotype x environment (linear) component against pooled deviation for grain yield suggested that the genotypes were diverse for their regression response to change with the environmental fluctuations. Similarly, the significant mean squares due to pooled deviation observed for all the characters under study suggested that the deviation from linear regression also contributed substantially towards the difference in stability of genotypes. 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 (Ahmad *et al.*, 2014).

The stability parameters for all cultivars are given in (Table 2). 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 adaptable genotype was defined as one with bi =1 and with S^2di=0.The mean performance of the cultivars across the environment revealed that the highest chlorophyll content was recorded in the cultivar SKO-90 followed by SKO-167. The population mean was 54.39. The other parameter (S^2di) that measured the mean square deviation from regression was non-significant for all the cultivars except Kent. Sko-90 and SKO-96 was observed most stable across the environments. For leaf area index the genotype SKO-90, SKO-96 and Sabzaar had non-significant bi value and almost approaching unity, associated with high mean and non-significant deviation from regression (S^2di), showing good adaption across the environment. Genotypes with high chlorophyll content and LAI were used as selection criteria to improve oat cultivars with high forage and grain yield. The same findings for the trait have been observed by Ahmad *et al.* (2013) and Siloriya *et al.* (2014).

The cultivars showing poor adaptation were SKO-117 and Kent. All other cultivars exhibited performance around the mean of the population. For seeds panicle^{-1} across the environment, SKO-98, SKO-166 and Sabzaar had non-significant bi value and almost approaching unity, associated with high mean and non-significant deviation from regression (S^2di) and found to possess good adaption across the environment. Similar findings for grain yield and its components have been observed by Akcura and Ceri, 2011; Ahmad *et al*., 2013; Ahmad *et al*., 2014 and Siloriya *et al.*, (2014).

Conclusion

Overall ranking of genotypes, the regression coefficient of genotypes viz., SKO-90, SKO-96, SKO-98 and Sabzaar 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 physiological traits. For grain yield and its contributing traits the genotypes SKO-98 and SKO-166 was found most desirable across the six diverse environments. The regression coefficient of these was almost equal to the unity and it had the lowest deviation from regression but put emphasis on the role of further evaluation both spatially and temporally so that the recommendation of the said genotypes can be suggested with authenticity.

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Table 1. Analysis of variance for physiological and grain yielding attributes in oats evaluated across six environments in the Kashmir valley

Source of variation	d.f	Mean squares					
		Leaf area index	Chlorophyll content	Spikelets panicle^{-1}	Seeds panicle^{-1}	1000 seed weight (g)	Grain yield plant^{-1} (g)
Genotypes	11	0.821**	49.637**	31.995**	94.629**	51.882**	1.257**
Environment + (Genotypes × Environment)	60	0.035**	0.761**	1337.64**	80.400**	8.214**	0.288**
Environment	5	0.111**	7.969**	1074.297*	757.130**	58.198**	0.816**
Genotypes × Environment	55	0.028**	0.105**	263.347	18.879**	3.670*	0.242*
Environment (linear)	1	0.556**	39.846**	1074.297**	3785.651**	290.991**	4.083**
Genotype × Environment (linear)	11	0.007*	0.030**	102.107**	27.357**	9.557**	0.764**
Pooled deviation (non-linear)	48	0.030**	0.051*	161.240**	15.363**	2.015**	0.256**
Pooled error	132	0.013	0.034	224.308	5.828	0.507	0.360

*, ** significant at 5 and 1 per cent level, respectively

Table 2. Stability parameters for physiological and grain yielding attributes in oats evaluated across six environments in the Kashmir valley

Genotypes	Leaf area index			Chlorophyll content			Spiklets panicle^{-1}			Seeds panicle^{-1}			1000 seed weight (g)			Grain yield plant^{-1} (g)		
	($\bar{X}$)	bi	$S^2 d_i$	($\bar{X}$)	b_i	$S^2 d_i$	($\bar{X}$)	b_i	$S^2 d_i$	($\bar{X}$)	b_i	$S^2 d_i$	($\bar{X}$)	bi	$S^2 d_i$	($\bar{X}$)	b_i	$S^2 d_i$
SKO-20	4.50	0.97	-0.01	54.12	1.60*	1.80	34.08	1.19	1.54	67.70	1.20	10.14	32.31	0.71	0.19	5.36	1.34	0.06
SKO-90	4.79	1.04	0.03	56.03	1.05	0.005	37.81	1.07	0.002	73.50	0.72	44.07	35.07	0.33*	-0.44	5.05	0.26	0.61**
SKO-96	4.95	1.02	0.03	55.55	1.00	0.004	36.77	1.01	0.04	72.31	0.65	29.52**	32.84	0.57*	-0.35	4.62	2.06	0.03*
SKO-98	4.43	1.47	0.01	55.65	0.82	2.67	34.68	0.92	0.47	68.26	1.06	0.03	35.00	1.10	0.03	4.47	1.02	0.03
SKO-117	4.28	0.86	0.05**	55.68	0.86	-0.27	33.30	1.27	-0.92	66.34	1.31	-3.32	34.31	0.45*	0.04	4.27	0.81	-0.03
SKO-148	4.59	0.29	0.001	54.80	0.91	-1.31	36.34	0.80	-1.21	71.06	0.82	-6.11	31.75	0.64	1.95**	4.47	-0.07	0.84**
SKO-160	4.06	0.94	-0.01	55.50	0.89	-0.85	38.54	0.90	1.72	73.41	0.97	6.59	31.91	0.59	1.68**	3.99	1.17	-0.01
SKO-166	4.59	0.61	0.01	54.24	0.66*	-1.25	39.83	0.82	2.67	77.22	1.03	0.04	34.68	1.14	0.02	4.39	1.03	0.07
SKO-167	3.85	1.09	-0.002	56.02	0.96	0.73	37.13	0.81	-0.79	73.41	0.93	6.30	39.70	1.43	0.33	4.83	1.10	0.10*
SKO-176	4.63	0.60	-0.01	56.00	1.16	-0.78	38.77	1.72*	-0.79	75.27	1.57	6.52	35.05	0.72	-0.24	5.34	1.64	0.37**
Population mean		36.20			54.39			36.20			70.87			34.57			4.35	
SE (m)		0.81			0.67			0.81			1.75			0.63			0.22	
SE (bi)		0.19			0.15			0.19			0.22			0.28			0.86	

*, ** significant at 5 and 1 per cent level, respectively