Short Research Article

Identification of stable genotypes for seed yield and related traits of oat (*Avena sativa* L.) under varied conditions of North-western Himalayas

Abstract

The present investigation was undertaken to determine the stability of oat genotypes for seed yield under varied environmental conditions prevalent in north- western Himalayas. A total of 121 genotypes including five checks were evaluated during three cropping seasons (Rabi 2015-16 to 2017-18). The stability was estimated using Eberhart and Russell model for six traits viz., days to 50% flowering, days to 75% maturity, biological yield per plant, harvest index (%), 1000-seed weight and seed yield per plant (g). The pooled analysis of variance showed differential behavior of genotypes over the environments. The most stable genotypes identified for days to 50% flowering, days to 75% maturity, biological yield per plant, harvest index (%) and 1000- seed weight were S8-217, UPO-119, Oats-17 and Oats-8655,respectively. However, the promising and stable genotypes for seed yield identified wereJPO-24 and Oat- 79. Thus, the genotypes found stable and well adapted to all the types of environments could be exploited as elite gene pool in future breeding programme, where aim is to develop high yielding and stable genotypes over environments or could be further tested in multilocation trials to be released as a cultivar.

Keywords: Seed yield, G×E interaction, Stability, *Avena sativa* genotypes

Introduction

Oat is a cereal crop of Mediterranean origin (Stevens *et al.* 2004). Preference to oat cultivation as a grain crop in Central and Western Europe and as fodder in Asia Minor is available since Christian era (Vavilov 1926). Oatis an economically important crop and ranks sixth in world cereal production after wheat, maize, rice, barley and sorghum.Oat seeds have good nutritional value with a high content of essential dietary minerals, unsaturated fatty acids, unique galacto-lipids and the highest levels of globular proteins amongst any cereal. They also have high levels of mixed (1→3), (1→4) β-D-glucans, which are beneficial for digestion and have cholesterol-lowering properties. Moreover, oat contains compounds such as tocopherols, inositol phosphates and avenanthramides which possess antioxidative properties (Chawade*et al.* 2010). Oat is generally grown in India for fodder purposes. But of late, its importance as grain has been felt because of the above benefits and efforts are now being made to develop oat varieties which could give high fodder yield as well as grain yield from the same crop.

In India, oat is cultivated in Himalayan states like Kashmir, Himachal Pradesh and Uttarakhand. Oats in these regions have a wider adaptability because of its excellent growing habitat, quick re-growth, better nutritional value and drought & cold tolerance ability. The climatic conditions changes very quickly in the Himalayan region due to change in the altitude. The climate here is very unpredictable and dangerous too.

One of the main issues to be considered in plantbreeding programs is the evaluation of changes in seedyield and quality of candidate or new cultivars underdifferent environments or seasons.The adaptability of a variety over diverse environments is usually tested by the degree of its interaction with different environments under which it is planted. The genotype x environment interactions could be attributed to predictable that may be due to macro-environmental conditions and non-predictable effects, mainly caused by climatic and micro-environmental conditions as reported by Allard and Bradshaw (1964). A variety is consideredmore adaptive or stable if it has a high mean ofyield with low degree of fluctuation in yield ability forgrowing over different locations or seasons (Amin et al. 2005).

Many models have been developed to measure the stability of various parameters. Among those the most widely used (Eberhart and Russell, 1966) model has been followed to interpret the stability statistics in various crops.He suggested that the regression coefficient (bi) and deviation from regression (S^2di) may be considered as two parameters for measuring the varietal phenotypic stability. The variety with (bi) value did not significantly differ from unity (bi=1) and (S^2di) did not significantly differ from zero could be described as a stable variety. Thus, the present investigation was undertaken to identify the promising and stable genotypes of oat under varied conditions of North-western Himalayas for seed yield.

Materials and Methods:

The experiment was conducted for three consecutive years from *rabi* 2015-16 to 2017-18at Experimental Farm of the Fodder Section, CSK HPKV, Palampur which is situated at 32°6’ N latitude, 76°3’ E longitude at an elevation of 1290.8 m (a.m.s.l). Agro-climatically the location represents the mid-hill zone of Himachal Pradesh (Zone-II) and is characterized by humid sub-temperate climate with high rainfall (2500 mm). The mean weather data i.e. temperature (˚C), rainfall (mm) and relative humidity (%) is given in figure 1. The soil is acidic in nature with pH ranging from 5.0 to 5.6 and soil texture is silty clay loam. The experimental material comprised of 121 oat germplasm lines including five checks *viz.*, Palampur-1, OS-6, Kent, RO-19 and UPO-212 were evaluated using simple lattice design. Each genotype was grown in two rows of 1m length with 25 x 5 (cm^2) spacing. The plot size was kept 1.0 x 0.5 m^2. The data was recorded on five randomly selected competitive plants in each replication on sixquantitative traits *viz.*,days to 50% flowering, days to 75% maturity, biological yield per plant, harvest index (%), 1000- seed weight and seed yield per plant (g). The data on these traits were subjected to stability analysis according to Eberhart and Russell (1966).

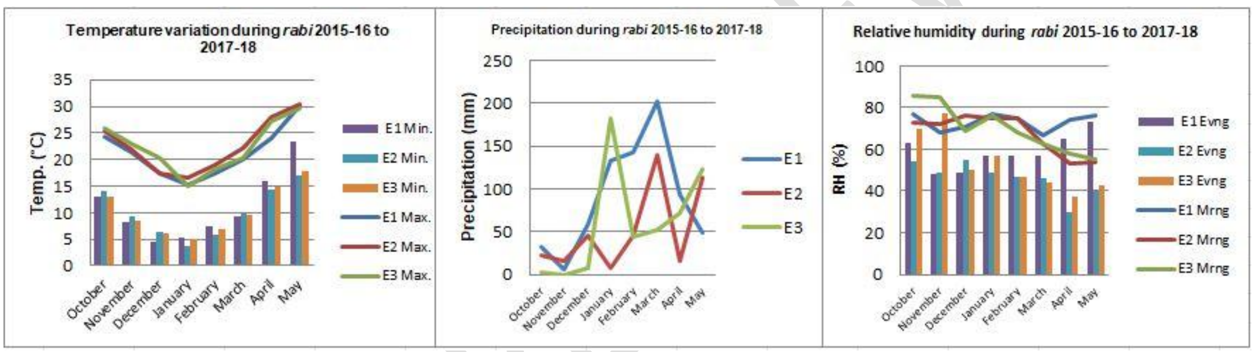

Figure 1: Mean monthly meteorological data at Palampur [October to May for each *rabi* season 2015-16 (E1), 2016-17 (E2) and 2017-18 (E3)]

Results and Discussions:

Significance of mean squares: The pooled analysis of variance (Table 1) showed significant differences among the genotypes and environments for all the traits studied,which revealed that there was considerable variation present both among the genotypes and environments.The magnitude of variation for Genotype × Environment interaction was significant for seed yield per plantand for E + (G × E) for all the traits except biological yield and 1000-seed weight, indicating that the genotypes interact strongly with the environments for these traits.Mean sum of squares for environment (linear) showed significance for all the characters.Also,the magnitude of genotypes and environmental variances was observed to be higher than of G × E interaction for all the traits. Furtherthe higher magnitude of mean squares due to the linear component of G × E than the non-linear component of G × E revealed that the considerable differences in the environments contributed for major part of total variation for most of the traits studied which was mainly due to variation in weather and temperature during different cropping seasons and hence, the performance of genotypes for seed yield could be predicted across the environments.

Table1: Joint regression analysis of variance for seed yield and related traits over environments

Source of variation	d.f	Days to 50% flowering	Days to 75% maturity	Biological yield per plant	Harvest index	1000-seed weight	Seed yield per plant (g)
Genotypes	**120**	142.69*	44.73*	379.96*	23.11*	84.36*	29.28*
Environments	**2**	1197.19*	5239.24*	3241.59*	520.05*	134.37*	210.22*
G ×E	**240**	21.27	12.03	204.3	12.57	10.57	12.60*
Environments + G ×E	**242**	30.99*	55.23*	229.4	16.77*	11.6	14.23*
Environment (linear)	**1**	2394.38*	10478.48*	6483.19*	1040.10*	268.73*	420.43*
G ×E (linear)	**120**	23.83*	13.36*	183.61	12.58*	10.42	17.61*
Pooled Deviation (non-linear)	**121**	18.55*	12.60*	223.13*	12.46*	10.64	7.52
Pooled error	**360**	5.43	6.19	50.18	5.05	8.9	6.28

*Significant at 5% level of probability

Variance due to G× E (linear) was significant for the traits *viz.*,days to 50% flowering, days to 75% maturity, harvest index and seed yield per plant (g)which depicted linear regression to be the major component for differences in stability and the performance can be predicted with some credence under different environments for these traits. Likewise, the significant variation due to pooled deviation or non-linear G× E component revealed that the deviation from linear regression also contributed towards the difference in stability of genotypes for days to 50% flowering, days to 75% maturity, biological yield per plant and harvest index.Thus, both linear (predictable) and non-linear (unpredictable) components contributed significantly to genotype x environment interactions observed for the traits but with the predominance of the former component suggesting that the performance of genotype acrossenvironments could be predicted with greater precision.Similar results were reported by Howarth*et al.* 2021, Singh *et al.* 2019, andDoehlert*et al.* 2001.The non-significance of linear mean square against pooled deviation for biological yield per plant and 1000-seed weight indicated that the reliable prediction of G× E interaction could not be made. However, even for unpredictable traits, prediction could be made based on stability parameters for individual traits (Singh *et al.* 1991).

Stability analysis:

The stability parameters (b_i&S^2_{di}) for all the traits were recorded (Table 2-3).According to regression model of stability proposed by Eberhart andRussell (1966), b_i is considered as a parameter of response and S^2_{di} indicates instability due to the deviationfrom zero. However, the significance of the coefficient of regression (b_i) means responsiveness either to favorableenvironment (b_i>1) or poor ones (b_i<1).

The mean values ranged from 131-157with average value of 144for days to 50% flowering.Considering the genotypes showing above average performance for all the traits, genotypes S8-217, JHO-813, OL-9 and UPO-102 with mean performance of 133, 135, 137 and 138 days to flowering, respectively were found stable over all the environments and based on their significant regression coefficients(b_i>1), the most responsive genotypes performed better under favourable environments were OS-9,JPO-25 and JPO-17.

The mean values ranged from 167-184with average value of 175for days to 75% maturity.GenotypesUPO-119, IG-03-48, PO-1, JPO-20, KRR-AK-06, OL-125, Oat-8655 and JHO-813 with high mean performance of 168, 170, 171, 171, 171, 172, 173 and 173 days to 75% maturitywere found stablewhile, the most responsive for favourableconditions were JPO-19, SKO-28, KRR-AK-15. Regarding biological yield per plant, the mean values ranged from 72.00-130.21with average value of 100.86 g. Genotypes, Oat-17 and IG-03-211 with above average performance of 115.71and 106.71 g biological yield per plant, were found stable with b_i values approaching to unity and non-significant S^2_{di}values (Table 4).The most responsive genotypes JPO-41 and OS-6were observed to perform better under favourable environmental conditions for this trait. For harvest index, the mean values ranged from 15.72-31.96% with average value of 23.19% andgenotypes, Oat-8655(25.59 %), OS-92(25.45 %), EC-528889 (24.7 %), UPO-119 (24.45 %), JPO-24 (24.11 %), JPO-45 (24.06 %), HFO-52 (24.05 %) and OG-77 (23.58 %) were found stable under all the types of environments.The mean values ranged from 21.53-44.52with average value of 32.94 gfor 1000-seed weight and genotypes IG-03-251(41.72 g), OG-77 (34.14 g), ADG-96 (34.07 g) and KUE (33.94 g)were found suitable and stable over all the environments.Based on significance of regression coefficient (bi>1), the most responsive genotypes for harvest index (UPO-130, JPO-30 & OS-9) and 1000-seedweight (EC-528890 and EC-558905) were identified. For the major character *i.e.* seed yield per plant, the mean values ranged from 14.63-32.75with average value of 23.06 g and only two genotypes,JPO-24(27.75g) and Oat- 79 (24.49 g) were well adopted to all the environments. Two genotypes, JPO-3 and IG-03-208showed significant bi values (bi> 1) were specifically adapted to most favorable environmental conditions depicting that even a smallchange in environment may result a large increase in response in these genotypes. Thus, the results indicated sufficient variation in the performance of genotypes under varied environmental conditions. The results were in confirmation with Lorencetti*et al.* (2002), Altaf *et al.* (2003), Akcura*et al.* (2005), Singh *et al.*(2019) and Howarth *et al.*(2021).

Conclusions:

Genotypes JPO-24 and Oat-79 were found stable and well adopted to all types of environments for seed yield per plant. However, genotypes JPO-3 and IG-03-208 were most responsive among all the genotypes and 99-1 and OL-9 were least responsive indicating their suitability for specific and poor environments, respectively.Hence, these genotypes may be included in any breeding programme where objective is to develop high yielding and stable genotypes over environments. Also these stable genotypes may further be tested at multi-locations to be released as a variety under north-western Himalayan conditions.

Table 2.Estimates of stability parameters for days to 50% flowering, days to 75% maturity, biological yield per plant andharvest index in oat

Genotypes	Days to 50% flowering		Days to 75% maturity		Biological yield per plant(g)		Harvest index(%)	
	bi	S^2 di	bi	S^2 di	bi	S^2 di	bi	S^2 di
99-1	0.57	-5.28	0.80	-1.60	0.60	83.64	-2.25	23.53*
ADG-214	-0.04	19.18*	0.79	74.45	2.19*	-50.41	1.02	-2.02
ADG-96	2.41**	-5.43	0.70	4.61	0.31	167.70*	1.81	-5.15
AVE-3018	1.39	7.00	1.21	5.55	-0.15	97.77	1.1	3.18
Chorripatli	-1.16	69.17**	0.75	-6.36	-1.20	-16.79	0.46	13.73
EC-523890	1.35	-3.39	0.48	70.85	2.25	531.15**	3.44	1.62
EC-528865	1.97	2.73	0.82*	-7.50	2.67	-44.56	1.86	-5.16
EC-528883	2.18	22.06*	1.03	29.22	-1.30	234.28*	2.15	0.2
EC-528889	1.42	27.54*	0.89	1.57	-2.11	1185.73**	0.97	-5.05
EC-528890	1.37	2.54	0.90	4.14	0.05	-25.81	1.78	0.47
EC-528894	2.47	28.19*	1.70	43.93	3.85	29.87	-0.64**	-5.39
EC-528895	2.32	25.05*	0.97	-5.18	1.47*	-50.69	1.09	-5.3
EC-528896	1.41	30.68*	1.56	-5.95	1.80	782.68**	1.46	-0.21
EC-528897	0.86	34.28**	0.92	7.94	-1.43	3174.35**	-1.02	-2.56
EC-528898	2.75	-4.42	0.98	1.53	1.33	83.22	1.01	-1.35
EC-528903	3.13	-1.31	0.90*	-7.55	2.84	606.22**	1.76	-4.57
EC-528905	2.06	-4.89	1.64	-5.55	0.28	2.06	0.85	-4.16
EC-528913	0.51	-1.98	0.47*	-7.46	1.16	221.62*	1.05	-1.72
EC-558905	-1.01	17.61*	1.06	0.08	-0.06	-21.61	2.16	4.11
EC-605831	2.91	98.44**	1.99	1.21	0.57	-1.01	0.44	-4.42
EC-605832	0.05	5.00	0.73	19.84	-2.13	1089.85**	-1.96	27.07*
EC-605834	1.09	11.73	0.83	-0.18	1.94	54.85	1.24	3.89
EC-605837	-0.69**	-5.45	0.59*	-7.48	4.10	-5.96	1.83	0.24
EC-605838	2.53*	-5.37	0.90**	-7.55	2.55	416.35**	2.23	-4.79
EC-605839	0.69	23.21*	0.82	-4.86	-1.71	149.17*	1.03	-1.85

Fragrati	1.05	8.76	1.33	-3.04	1.28	-47.94	-0.24	-3.88
H-B-8	0.83	18.55*	1.03	-6.52	1.27	-26.56	0.88*	-5.36
HFO-102	2.99	-3.90	0.99	9.14	-1.81	3.41	1.93	44.91**
HFO-114	-0.76	1.03	0.65	-2.97	3.14	-46.52	1.61	-3.36
HFO-163	0.34	1.72	0.64	-2.39	-2.75	59.67	1.02	5.04
HFO-52	0.29	0.00	0.74**	-7.55	-0.74	0.98	0.86	-4.19
HJ-8	0.51**	-5.44	0.88	-7.04	0.71	15.59	2.19	-5.13
IG-03-203	1.16	4.26	0.51	37.47	2.56	103.20	1.8	-3.72
IG-03-205	0.53	-4.84	1.09	-5.10	3.92	179.80*	2.08	-3.47
IG-03-208	1.99	23.09*	0.85	20.10	4.13	330.73**	2.08	19.61*
IG-03-211	2.28	-3.96	1.33	54.86	0.96	-40.08	2.47	-2.07
IG-03-213	0.52	15.29	1.04	21.96	0.94	147.54*	-0.12	15.12
IG-03-214	0.96	-1.68	1.19	10.88	1.13	-35.35	0.81	-3.93
IG-03-216	0.09	-2.11	0.65	-7.11	2.21	247.46*	-0.17	-5.34
IG-03-246	1.73	1.88	1.33*	-7.49	-0.18	1115.20**	0.54	42.25**
IG-03-247	-0.29	-3.95	0.89	-4.34	-1.59	65.98	1.67	30.91**
IG-03-250	-0.66	9.91	0.80	49.97	-0.72	-20.16	1.05	5.69
IG-03-251	-1.01	105.05**	0.72	-6.45	-2.72	193.17*	-0.21	57.29**
IG-03-254	1.44	5.19	1.09	18.62	1.94	88.27	1.03*	-5.38
IG-03-48	0.21	10.81	0.91	11.24	-0.09	-46.99	1.03	-2.5
IGO-14	-0.54	32.04**	0.59	1.84	0.89	185.94*	0.87	-5.04
JH0-862	1.40	2.88	0.86*	-7.43	-2.97	91.83	-0.05	116.78**
JHO-813	0.64	-3.38	0.97	3.14	3.88	90.35	1.62	-1.07
JHO-822	-0.15	-1.22	0.87	-6.30	1.24	-50.22	1.03	15.31
JHO-99-2	-0.53	-4.84	0.72	-6.45	-0.77	-9.76	-2.34	3.18
JPO-10	1.25	19.86*	0.47*	-7.46	-1.11	266.55*	2.38	-0.17
JPO-13	0.84	-5.38	1.47	-3.89	1.73	40.83	2.21	-4.53
JPO-14	-0.75	125.49**	0.71	8.39	2.83	644.16**	-0.09	2.98
JPO-17	2.64*	-5.32	1.85	-2.44	1.71	149.17*	1.77	-4.06
JPO-18	0.73	-3.52	1.32	63.16	1.57	172.34*	1.1	-4.83
JPO-19	1.29	62.02**	1.73*	-7.06	1.00	310.24**	1.98	-2.91
JPO-20	0.31	-5.18	0.94	-3.26	1.94	136.46	2.63	9.07
JPO-21	2.49	6.61	1.22	13.00	3.79	-28.69	1.25	9
JPO-22	1.15*	-5.38	0.62	-4.07	1.30	-7.51	1.91	-4.92
JPO-24	0.42	-2.73	0.74**	-7.55	-0.22	239.33*	0.89	5.35
JPO-25	3.39*	-4.23	0.33	-6.56	0.00	13.46	-1.16	26.40*
JPO-28	0.84	-3.15	1.21	-4.49	-0.88	-45.78	1.51	7.11
JPO-29	3.14	5.46	2.16	7.90	0.03	108.58	-1.78	112.46**
JPO-3	2.13	5.29	1.16	2.04	0.11	-13.08	1.24	0.29
JPO-30	1.78	28.37*	1.02	0.79	3.28	360.71**	1.52*	-5.38
JPO-31	-0.32	21.16*	1.15*	-6.87	1.46	-38.05	-0.6	1.72
JPO-35	0.90	119.21**	1.14	6.66	1.37	215.73*	2.04	-0.63
JPO-36	0.90	53.95**	1.10	12.78	4.01	53.00	1.26	11.8
JPO-38	-0.18**	-5.44	0.52	-7.37	-2.12	-2.25	0.01	-0.07
JPO-4	2.10	0.49	1.09	-5.10	4.01	-38.98	-0.38	1.03
JPO-40	0.24	-5.40	1.06*	-7.22	-1.39	74.12	1.91	2.27
JPO-41	1.13	-4.78	1.54	26.14	3.53*	-50.41	2.01	-2.87
JPO-44	2.24	255.63**	0.61	-2.42	-1.36	-49.54	1.22	11.14
JPO-45	1.51	85.19**	0.29	-6.79	0.46	121.60	0.85	-0.91
JPO-46	2.08	22.57*	1.70	20.59	4.48	543.28**	1.27	37.03**
JPO-5	1.44	-3.25	1.59	3.16	1.19	14.25	2.58	23.20*
JPO-50	1.92	13.16	0.97	-5.18	1.54	100.67	1.09	-0.8
JPO-55	0.59	2.91	1.28	1.88	1.25	-42.77	-0.11	-3.03
JPO-73	1.70	17.46*	0.78	18.55	2.95	36.67	1.34	13.58
JPO-8	1.93	49.92**	0.60	8.58	0.18	-2.85	-0.75*	-5.38
K-353	-0.09	-2.11	0.80	0.12	0.72	3.04	-0.42	19.51*

KRR-AK-06	0.01	35.71**	1.01**	-7.55	-0.79	14.91	0.04	2.77
KRR-AK-15	1.35	9.79	1.50*	-7.04	1.75	8.92	4.4	-2.66
KRR-AK-26	1.24	5.12	1.38*	-6.95	2.37	119.12	1.09	-5.32
KRR-AK-36	1.90	7.59	1.08	7.16	-2.11	687.03**	2.86	8.42
KRR-AK-42	-0.10	22.53*	0.88	-0.68	-2.19	128.14	0.23	59.96**
KUE	0.91	-3.78	1.08*	-7.31	1.94	180.81*	1.48	-4.89
No. 77	0.49	-5.07	0.80	-1.60	-1.55	-14.65	0.28	-5.21
Oat-102	0.44	-4.56	0.67	-7.28	1.99	-48.41	0.58	-1.32
Oat-17	0.60	-2.16	0.95	-1.44	0.77	-23.00	1.21	-4.28
Oat-79	0.36	-1.55	0.39	20.15	0.66	74.07	1.26	-2.38
Oat-80	2.02	-0.82	1.24	3.58	0.01	62.21	3.94	27.74*
Oat-8655	-1.63	58.49**	0.97	91.53	-0.24	383.70**	0.91	13.06
Oat-902	0.51**	-5.44	1.16	2.04	3.34	245.21*	1.16	-4.64
OG-77	-0.53	13.42	0.48	46.96	-0.82	178.48*	0.93*	-5.39
OL-125	0.31	-3.87	0.91	-6.79	-1.36	340.14**	-0.95	-0.29
OL-161	1.24*	-5.36	0.91	-6.79	3.37	-2.98	0.91	12.18
OL-822	1.26	4.57	0.81	-3.39	1.67	439.48**	1.44	0.43
OL-9	1.00	-3.91	1.20	2.82	4.08	1269.47**	2.81	-4.54
OS-10	0.54	26.26*	0.80	25.88	0.27	-24.62	1.07	50.47**
OS-121	2.48	11.98	1.59	-3.80	-0.11	110.48	0.66	-4.96
OS-9	3.72*	-4.60	1.96	28.77	2.15	83.13	1.31*	-5.35
OS-92	-0.22	-3.74	1.10	-2.83	0.42	-26.48	0.76	-5
PO-1	0.48	-5.24	1.00	-2.65	3.29*	-49.51	1.48	0.47
S8-217	0.71	-4.98	1.13	-3.95	1.75	224.97*	1.69	-1.66
Sabzaar	0.04	-5.31	1.09	-4.40	3.98	-0.37	3.3	2.81
SK-150	2.43	13.88	1.37*	-7.41	-2.78	740.93**	-2.89	18.48*
SK-199	0.27**	-5.43	0.91	11.24	2.10	-39.51	1.01	-0.39
SKO-28	2.30*	-5.18	1.54*	-7.20	2.96	-35.85	-1.06	-3.32
SNTM-90	0.18**	-5.44	0.55**	-7.53	1.21	861.39**	0.03	30.52*
TRS-106	1.89	22.49*	0.65	-2.97	-0.77	-44.72	-0.14	21.79*
UPO-102	0.63	9.76	1.11	-2.54	0.52	-31.80	1.52	13.96
UPO-102-1649	1.15*	-5.38	1.14	-2.27	3.84	-42.37	0.32	16.90*
UPO-119	-0.77	2.35	0.93	-4.78	1.62	-4.24	0.82	-5.09
UPO-130	1.86	4.35	0.68	-6.66	1.63	-49.36	2.45*	-5.19
UPO-30	1.84*	-5.38	1.08	30.75	0.43	474.07**	1.6	-3.52
Kent (C)	0.38	-3.83	1.10	-2.83	0.49	-32.97	0.38	-5.37
OS-6 (C)	2.29	11.17	1.53	11.22	3.46**	-50.69	1.58	-1.96
PLP-1 (C)	1.22	-4.86	0.66	-5.00	1.10	2.66	1.71	5.37
RO-19 (C)	-0.62	-4.91	0.87	-6.99	4.04	188.81*	0.15	53.83**
UPO-212 (C)	-0.49	-5.07	0.51	-3.96	1.38	-5.91	-0.26	19.94*
Grand mean	1.00	-	1.00	-	1.00	-	1	-
S.E (m) ±	1.00	-	0.40	-	2.00	-	1.2	-

,* Significance at 5 and 1% of deviation regression from zero in case of S^2_{di}**(mean square deviation)** and of regression coefficient from unity in case of b_i **(regression coefficient).**

Table 3.Estimates of stability parameters for 1000-seed weight and seed yield per plant in oat

Genotypes	**1000-seed weight (g)**		**Seed yield per plant(g)**		**Genotypes**	**1000-seed weight (g)**		**Seed yield per plant(g)**	
	bi	**S^2 di**	**bi**	**S^2 di**	**JPO-25**	3.74	11.69	-1.07	-2.68
99-1	4.64	-4.82	-3.54*	-6.47	**JPO-28**	-0.88	-5.44	3.1	-6.37
ADG-214	3.81	-9.58	-0.02	-6.7	**JPO-29**	0.5	-3.18	0.7	232.51**

ADG-96	0.87	-7.8	3.98	-6.19	**JPO-3**	5.75	-9.19	1.50*	-6.69
AVE-3018	0.37	-6.56	1.43	-6.61	**JPO-30**	0.15	-10.15	-1.22*	-6.69
Chorripatli	0.33	-7.38	1.39	-6.62	**JPO-31**	-3.24	-3.01	-0.99	15.1
EC-523890	-0.89	-1.51	0.02	-6.7	**JPO-35**	-1.67	-5.41	1.19	-6.63
EC-528865	0	-0.61	1.82	-5.42	**JPO-36**	-0.04	-10.77	0.52	45.65**
EC-528883	0.19	-9.69	5.99	-5.63	**JPO-38**	0.6	0.37	2.39	-6.5
EC-528889	0.003	-10.83	6.46	-5.47	**JPO-4**	-0.45	-10.77	-1.37	75.11**
EC-528890	1.20*	-10.82	2.79	-6.43	**JPO-40**	-2.41	-9.26	5.62	-5.75
EC-528894	0.23	-9.2	-2.95	10.81	**JPO-41**	0.63	1.4	0.62	-6.68
EC-528895	0.06	-10.7	1.12	-6.64	**JPO-44**	-0.87	12.59	3.16	-6.37
EC-528896	0.74	1.7	-0.49**	-6.71	**JPO-45**	0.42	-5.29	0.32	-6.69
EC-528897	0.13	-10.26	4.74	55.48**	**JPO-46**	0.31	-7.83	0.48	-6.68
EC-528898	0.22	-9.33	1.46	-6.61	**JPO-5**	1.31	-9.72	0.84	39.26**
EC-528903	0.84	-9.67	-0.96*	-6.7	**JPO-50**	0.45	-4.49	1.7	-6.58
EC-528905	6.78	10.37	0.71	-6.35	**JPO-55**	-0.2	-9.61	-1.49*	-6.68
EC-528913	0.4	-5.81	-0.44**	-6.71	**JPO-73**	1.44	-6.81	0.13	-6.7
EC-558905	1.05*	-10.83	1.68	27.83*	**JPO-8**	-1.17	31.50*	-1.47*	-6.68
EC-605831	0.59	1.39	0.82*	-6.7	**K-353**	6.58	-4.54	-0.87	-5.41
EC-605832	1.26	76.89**	2.39	-6.5	**KRR-AK-06**	1.74	1.74	0.39	-6.62
EC-605834	1.5	8.91	1.05	-6.18	**KRR-AK-15**	-1.5	-7.98	7.17	-5.19
EC-605837	0.54	-8.95	-0.62	-6.66	**KRR-AK-26**	0.02	-10.82	-1.06*	-6.7
EC-605838	0.9	-9.7	-0.38**	-6.71	**KRR-AK-36**	0.21	-9.43	8.82	-4.48
EC-605839	-0.36	-8.99	4.13	-6.16	**KRR-AK-42**	3.07	-4.4	-1.56	129.76**
Fragrati	0.56	-10.48	-1.20*	-6.69	**KUE**	1	-9.48	-0.09	-6.7
H-B-8	-4.15	-7.41	0.15	-6.7	**No. 77**	1.17	-10.34	1.97	-3.83
HFO-102	-0.8	-5.2	4.29	-6.12	**Oat-102**	6.15	4.73	-0.51**	-6.71
HFO-114	1.52	-0.83	0.51	-6.3	**Oat-17**	0.17	-10.39	1.3	-6.62
HFO-163	0.4	-5.78	2.47	15.39	**Oat-79**	4.35	-1.19	1.02	-6.65
HFO-52	9.67	89.04**	2.86	-6.42	**Oat-80**	-1.45	18.51	4.21	-6.14
HJ-8	-0.84	-3.31	3.47	-6.31	**Oat-8655**	0.18	-10.53	0.52	-6.68
IG-03-203	-1.04	22.52	-0.39	-5.71	**Oat-902**	3.19	91.33**	-1.63*	-6.67
IG-03-205	1.85	-7.9	-1.28*	-6.69	**OG-77**	1.01	-10.3	3.36	-6.33
IG-03-208	-0.88	-7.75	1.27*	-6.7	**OL-125**	1.31	27.82	1.64	-6.59
IG-03-211	0.92	-10.67	3.23	-6.35	**OL-161**	1.02	-3.55	-0.72**	-6.71
IG-03-213	2.74	-9.34	0.15	-6.7	**OL-822**	5.37	-6	2.96	-6.4
IG-03-214	3.52	-5.34	0.63	-6.67	**OL-9**	0.75	76.38**	-2.50*	-6.62
IG-03-216	3.37	34.60*	-3.36	-5.5	**OS-10**	-0.21	-9.44	3.67	42.29**
IG-03-246	-3.81	-4	-1.22*	-6.69	**OS-121**	4.03	-1.22	2.26	-6.51
IG-03-247	-1.6	-9.92	3.7	-6.26	**OS-9**	-0.2	-9.57	-0.60**	-6.71
IG-03-250	0.22	-4.56	1.99	-6.55	**OS-92**	1.09	30.87	1.25	-6.63
IG-03-251	0.91	15	1.25	-6.63	**PO-1**	6.72	2.31	0.05	-6.7
IG-03-254	2.09	-1.87	-0.64**	-6.71	**S8-217**	2.77	6.84	2.51	-6.48
IG-03-48	0.66	-1.52	1.34	-6.62	**Sabzaar**	-0.37	0.46	2.3	-6.51
IGO-14	-0.47	-2.36	-0.63	-5.8	**SK-150**	0.17	-9.96	0.89	-6.66
JH0-862	0.36	1.57	2.85	2.15	**SK-199**	-0.29	-8.29	0.14	-6.7
JHO-813	3.45	-6.77	-1.55*	-6.68	**SKO-28**	0.56	-1.08	-2.38	26.29*
JHO-822	1.14	-4.94	-0.26	5.7	**SNTM-90**	1.26	-10.14	1.77	-6.58
JHO-99-2	2.82	-1.45	-1.90*	-6.66	**TRS-106**	1.38	-7.64	1.57	0.64
JPO-10	0.2	-9.54	7.38	-5.11	**UPO-102**	3.24	-9.04	0.01	14.02
JPO-13	2.48	-2.64	1.22	-6.63	**UPO-102-1649**	-0.09	-10.57	-2.36*	-6.62
JPO-14	0.65	2.13	-2.23	7.76	**UPO-119**	3.4	-4.2	-0.61**	-6.71
JPO-17	0.5	-3.12	0.33	-6.69	**UPO-130**	2.19	-0.3	1.72	-6.58
JPO-18	0.54	-1.61	-0.61**	-6.71	**UPO-30**	-4.88	-5.82	4.17	-6.15
JPO-19	0.54	-1.57	3.48	-6.3	**Kent (C)**	1.02	-9.94	0.69	-6.45
JPO-20	0.94	-9.3	3.14	-1.86	**OS-6 (C)**	0.87	-4.19	0.32	-6.69
JPO-21	-0.32	-7.75	-0.64**	-6.71	**PLP-1 (C)**	-0.09	-1.55	1.83	5.31

JPO-22	0.37	-9.54	2.26	-6.51	**RO-19 (C)**	0.87	-10.68	-1.76	-6.23
JPO-24	4.52	22.24	0.83	-6.66	**UPO-212 (C)**	0.44	15.15	-0.98*	-6.7
					Grand mean	1	-	1	-
					S.E (m) ±	2.19	-	1.47	-

,* Significance at 5 and 1% of deviation regression from zero in case of S^2_{di}**(mean square deviation)** and of regression coefficient from unity in case of b_i **(regression coefficient).**

Table 4: Distribution of oat genotypes on the basis of performance, responsiveness and stability for different traits

Traits	**Performance**		**Responsiveness**		**High mean, unit regression and non-significant deviation from regression**
	Best performing	**Poor performing**	**Most responsive**	**Least responsive**	
Days to 50% flowering	UPO-119	EC-528894	OS-9, JPO-25, JPO-17	SNTM-90, JPO-38	S8-217, JHO-813, OL-9 and UPO-102
Days to 75% maturity	EC-605837	EC-528894	JPO-19, SKO-28, KRR-AK-15	EC-528913, JPO-10	UPO-119, IG-03-48, PO-1, JPO-20, KRR-AK-06, OL-125, Oat-8655 and JHO-813
Biological yield per plant (g)	EC-528865	UPO-212	JPO-41, OS-6	JHO-862, SK-150	Oat-17 and IG-03-211
Harvest index(%)	JHO-99-2	JPO-29	UPO-130, JPO-30, OS-9	JPO-8, EC-528894	Oat-8655, OS-92, EC-528889, UPO-119, JPO-24, JPO-45, HFO-52 and OG-77
1000-seed weight(g)	HFO-52	JPO-19	EC-528890, EC-558905	UPO-30	IG-03-251, OG-77, ADG-96 and KUE
Seed yield per plant (g)	EC-528865	OS-9	JPO-3, IG-03-208	99-1, OL-9	JPO-24 and Oat- 79

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