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SELECTION OF STABLE RAPESEED (*BRASSICA NAPUS* L.) GENOTYPES THROUGH REGRESSION ANALYSIS

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Abstract

Twenty-five elite genotypes of winter rapeseed were evaluated through regression analysis for their phenotypic stability in seven cold and six mild cold regions of Iran. Sufficient GE interaction was exhibited by the genotypes for seed yield which is pre-requisite to regression and stability analysis Across the 13 environments, Alice and Olera genotypes were at par and produced 3.40 t/ha. Thirteen genotypes showed above average mean performance. Erumia (cold) and Islamabad (mild cold) regions with yield of 4.35 t/ha were found suitable for this germplasm. Both linear as well non-linear components of GE interaction were significant and reflected the differential response of the tested genotypes to different environmental changes. Regression coefficients ranged from 0.29 to 1.35 in Syn-1 and DP-94-8 respectively. Four genotypes (Symbol, Fornax, Parade and Okapi) had b-values close to unity with average performance and low deviation from regression (S^2d), and were suitable for wider range of environments. Orient, Cocktail, Alice, Olera, Reg x Cob and SML-046 were found suitable for favourable environments due to their regression coefficients greater than unity, above average performance and low S^2d. Due to below average response (b<1) and least S^2d, Eurol, Hansen, Colvert, Mohican, Orkan and VDH-8003 were suitable for poor environments. The performance of GWC, Licord and Consul was unpredictable because of their significant S^2d.

Introduction

Information about phenotypic stability is useful in selecting crop varieties for general cultivation as well as for breeding programme. The phenotypic performance of a genotype is not necessarily the same under diverse agro-ecological conditions. Some genotypes perform well in some environments but do not in others. Genotype x environment (GE) interactions as explained by Hebert *et al*., (1995) are of notable importance in the development and evaluation of plant varieties as they reduce the stability of genotypic values under diverse environments. Given the prevalence of GE interaction, use of the regression coefficient (b-values) and deviation from regression (stability indices) provide information permitting more effective comparisons of different genotypes for yield and adaptation across the varied locations. Many workers like Ali *et al*., (2001), Khan *et al*., (1998), Mirza *et al*., (2002), Ahmed *et al*., (1996), Finlay & Wilkinson (1963) described the importance of genotype x environment interaction in stability analysis.

In Iran, rapeseed and mustard are edible oil crops and has recently been exploited to boost their production. The genotypes included in the present study were introduced from diverse sources of the world and have great yield potential. Iran has diverse agro-ecological region in order to increase area and production of rapeseed there is a need to identify a stable genotype suitable for these regions. In the present investigation, an attempt was made to study the stability of these winter rapeseed genotypes using regression analysis of Eberhart & Russell (1966) across diverse agro-ecological conditions in 13 provinces of Iran.

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Materials and Methods

Twenty five elite genotypes of winter rapeseed (*Brassica napus* L.) were studied for stability parameters in 13 locations in two regions (cold and mild cold) during 2000-01. The temperature of cold region varied from below –14°C (min) and 37-39°C (max); whereas in case of mild cold region, temperature ranged from –7 to –14°C (min) and 40 to 42°C (max). In cold region, the trial was conducted at 7 locations viz., Hamadan, Erumia, Shehrekurd, Zanjan, Arak, Miandoab and Kordestan, while in mild cold region at 6 locations viz., Zarghan, Islamabad, Esfahan, Karaj, Qazvin and Elam. The trial was organized by Oilseed Research Department, Seed and Plant Improvement Institute (SPII), Karaj, Iran. The trials were planted during September 1- 20 in cold region and September 10-25 in mild cold region. All the locations received N:P:K @ 150:60:100 kg/ha uniformly at the time of planting, whereas, nitrogen was splitted into two applications i.e., half at planting and half at bud formation stage. Sowing was done in randomized complete block design with 4 replications in each of the above environments. The experimental plot consisted of 4 rows of 5 m length in each replicate. The spacing adopted was 30 cm between rows and 10 cm within row. Other cultural operations were uniform at each location of the experiment. Central two rows were harvested and yield data recorded.

The mean data were utilized for analysis of variance of each location and pooled analysis of variance according to Steel & Torrie (1985). The stability analysis was carried out using Eberhart & Russell (1966) Model. The significance of regression coefficient was done by t-test.

Results and Discussion

Mean performance

Differences in mean yield performance of 25 genotypes of winter rapeseed were significant in 6 cold and 4 mild cold locations indicating sufficient amount of variation among the genotypes (Table 1). At rest of the locations (1 cold and 2 mild cold), the differences were found non significant.

Table 1. Mean, mean squares and coefficient of variation (CV%) of different 25 genotypes of winter rapeseed at 13 varied locations during 2000-2001.

Cold regions	Location means	Mean squares	CV%
Hamadan	3.13	0.743^{**}	10.02
Sherekurd	2.85	1.683^{**}	23.66
Kurdestan	2.72	0.499^{NS}	26.71
Zainjan	2.88	1.531^{**}	20.04
Arak	1.84	0.224^{**}	15.31
Miandoab	3.49	1.333^{**}	12.24
Erumia	4.36	1.932^{*}	21.63
Mild cold regions			
Zargan	2.54	0.944^{**}	19.81
Isfahan	2.28	0.464^{**}	14.48
Islamabad	4.35	3.041^{NS}	19.73
Elam	3.23	1.397^{NS}	30.10
Karaj	3.12	1.175^{**}	15.95
Qazvin	1.75	0.439^{**}	27.15

* Significant at 5%
**Significant at 1%
^{NS}Non-significant

Table 2. Mean yield (t/ha) performance of different genotypes at different locations in Iran.

Variety	Hamadan	Sherekurd	Kurdestan	Zanjan	Arak	Miandoab	Erumia
	Cold regions						
DP-94-8	2.64	2.47	2.52	3.33	1.58	2.86	5.32
Symbol	2.70	2.22	2.40	2.40	1.78	3.12	3.79
EUROL	2.76	2.78	2.71	2.51	2.08	2.27	2.99
ORIENT	2.80	2.68	2.78	2.99	1.65	3.70	4.82
HANSEN	3.03	2.44	2.82	2.46	2.25	3.16	3.93
COLVERT	2.77	2.75	2.36	2.10	1.72	2.94	3.27
MOHICAN	3.33	3.99	2.54	3.63	1.86	3.83	4.48
COCKTAIL	3.62	3.93	3.22	2.66	1.76	3.62	5.19
ORKAN	3.40	3.00	2.78	3.78	1.89	2.81	4.09
PF-7045-91	2.51	2.29	2.58	1.71	1.50	4.17	4.69
GWC	3.33	3.49	3.64	3.24	1.54	3.13	4.17
FORNAX	3.21	2.53	2.87	2.67	1.64	2.53	4.87
LICORD	3.09	2.74	3.15	3.25	1.95	4.51	3.84
ALICE	3.55	2.65	2.59	3.75	1.72	3.91	4.87
PARADE	3.66	3.45	2.93	3.22	2.20	2.97	4.66
SYN-1	2.82	2.10	2.87	2.15	2.28	3.65	2.98
VDH-8003	3.17	2.76	2.78	2.88	2.05	3.60	3.54
AKAMAR	2.64	3.44	2.92	3.15	1.89	4.48	4.20
CONSUL	3.45	4.14	2.67	2.43	1.92	3.12	5.15
OKAPI	3.11	2.80	2.53	2.78	1.84	3.80	4.14
L-I	2.66	3.66	3.17	2.59	1.58	3.83	4.77
OLERA	4.13	2.94	2.76	3.73	2.15	3.80	4.73
REG X COB	3.34	1.77	2.82	3.38	1.77	4.11	5.31
HYOLA-42	2.71	2.12	2.26	1.60	1.44	3.70	4.09
SLM-046	3.85	2.03	1.95	3.45	1.83	3.70	5.11
Location mean	3.13	2.85	2.72	2.88	1.84	3.49	4.36
	Mild cold regions						
	Zarghan	Isfahan	Islamabad	Elam	Karaj	Qazvin	Mean*
DP-94-8	2.32	2.29	4.94	3.37	3.00	1.28	2.92
Symbol	1.81	1.50	4.03	3.45	2.70	1.36	2.56
EUROL	2.93	2.06	4.47	3.30	2.23	1.88	2.69
ORIENT	3.17	1.90	4.97	4.12	3.30	1.41	3.10
HANSEN	2.52	2.14	3.71	3.23	2.75	1.62	2.77
COLVERT	1.39	1.91	3.85	2.96	2.85	1.64	2.50
MOHICAN	2.42	2.46	4.26	3.17	2.29	1.79	3.08
COCKTAIL	3.16	2.56	5.36	3.33	3.06	1.96	3.34
ORKAN	2.34	2.35	3.97	2.48	3.61	2.15	2.97
PF-7045-91	2.19	2.53	5.06	2.58	2.58	1.61	2.77
GWC	3.21	2.14	4.73	2.36	2.74	1.80	3.04
FORNAX	3.07	2.43	4.44	3.14	3.18	1.48	2.93
LICORD	2.41	2.39	3.66	4.08	2.63	1.91	3.05
ALICE	2.73	2.92	5.35	4.26	3.59	2.28	3.40
PARADE	2.81	2.76	5.22	3.92	3.50	1.95	3.33
SYN-1	2.39	2.57	2.32	2.48	3.47	1.85	2.61
VDH-8003	2.57	2.15	4.46	3.79	3.37	2.25	3.03
AKAMAR	2.02	1.90	4.48	2.41	2.51	1.29	2.87
CONSUL	2.20	2.02	4.56	2.72	2.71	1.50	2.97
OKAPI	2.76	2.11	4.45	2.44	3.54	1.62	2.92
L-I	2.03	2.03	4.51	3.18	2.67	1.48	2.94
OLERA	3.37	2.84	5.22	3.10	4.06	1.38	3.40
REG X COB	2.15	1.99	4.60	4.20	4.06	2.39	3.18
HYOLA-42	2.48	2.65	1.61	3.39	4.00	1.73	2.60
SLM-046	3.02	2.40	4.67	3.29	3.55	2.28	3.17
Location mean	2.54	2.28	4.35	3.23	3.12	1.75	2.96

*Mean of 13 locations (both cold and mild cold regions).

Table 3. Pooled analysis of variance for stability of seed yield in 25-winter rapeseed varieties.

Source of variation	DF	Mean squares
Genotypes (G)	24	0.866^{**}
Environment (E)	12	16.123^{**}
E + (GxE)	300	0.898^{**}
E (linear)	1	180.197^{**}
GxE (linear)	24	0.716^{**}
Pooled deviation	275	0.263^{**}
Pooled error	975	0.104

**Indicates significance at the 0.01 level of probability.

Across the locations, Alice and Olera were at par in producing 3.40 t/ha yield followed by Cocktail (3.34 t/ha) and Parade (3.33 t/ha). Out of all the tested genotypes, 13 genotypes produced greater yield than overall mean (2.96 t/ha) showing their above average mean performance (Table 2). Cocktail performed better at different locations and it was at the top at Islamabad (5.36 t/ha) closely followed by Alice (5.35 t/ha). The high yielding genotype Alice on overall mean basis also gave the highest yield at Elam (4.26 t/ha) and Isfahan (2.92 t/ha). This variety performed better at three other locations viz., Islamabad (5.35 t/ha), Zanjan (3 t/ha) and and Isfahan (2..75 t/ha) and Qazvin (2.28 t/ha). Another high yielding variety Olera with yield of 3.40 t/ha on overall locations basis, was also found highest yielder at Hamadan (4.13 t/ha), Karaj (4.06 t/ha) and Zarghan (3.37 t/ha). Other two varieties viz., DP-94-8 and Reg x Cob also produced high yields of 5.32 and 5.31 t/ha, respectively at Erumia (cold location). Among all the locations, Erumia (cold) and Islamabad (mild cold) followed by Miandoab (cold) were found suitable for this germplasm with yield values of 4.36, 4.35 and 3.49 t/ha, respectively.

Genotype x environment interactions

Pooled analysis of variance (Table 3) indicated significant genotype x environment interaction ($P < 0.01$) and showed the influence of changes in environments on the yield performance of the genotypes evaluated. Similar findings have been reported by Ali *et al*., (2001) in groundnut, Mirza *et al*., (2002) in soybean, Khan *et al*., (1988) in chickpea, Wani (1992) in Brassica and Khan *et al*., (1988) in sorghum. Genotype by environment interaction was partitioned in two components, linear and non linear. Both of these components were significant and reflected their importance in the determination of the differential response of genotypes to different environmental changes. Such similar results have been reported by Mirza *et al*., (2002). Highly significant environment (linear) also showed that the response of genotypes to changes in the environments was under genetic control. Ali *et al*., (2001) and Mirza *et al*., (2002) also reported consistent results. As the deviation from regression is also significant, it is obvious that differences in genotypic stability were due to both linear as well as non-linear components. This finding is not in line with those published by Ali *et al*., (2001) and Dhillon *et al*., (1999). As explained by Eberhart & Russell (1966), linear (bi) and non linear (S^2d) should be considered while judging the phenotypic stability of a variety. They also emphasised that an ideal variety should have high mean performance, b-value near to unity and S^2d as small as possible. Regression coefficient is a measure of response and deviation from it is a measure of stability (Khan *et al*., 1988; Yadav & Kumar, 1983; Yadav & Kumar, 1978.

Table 4. Stability parameters for 25 entries of winter rapeseed.

Genotypes	Mean yield (t/ha)	Genotypic variance	b	S^2d	R^2
DP-94-8	2.916	1.328	1.35**	0.15	90
Symbol	2.557	0.730	1.01**	0.08	90
Eurol	2.689	0.464	0.62**	0.23	54
Orient	3.098	1.222	1.31**	0.11	92
Hansen	2.773	0.410	0.76**	0.04	90
Colvert	2.500	0.513	0.80**	0.11	80
Mohican	3.081	0.830	0.97**	0.24	73
Cocktail	3.341	1.129	1.24**	0.15	88
Orkan	2.972	0.536	0.74**	0.19	67
PF-7045-91	2.768	1.311	1.27**	0.28*	81
GWC	3.038	0.835	0.95**	0.28*	69
Fornax	2.928	0.887	1.07**	0.15	84
Licord	3.045	0.656	0.81**	0.25*	64
Alice	3.397	1.091	1.22**	0.15	87
Parade	3.325	0.825	1.06**	0.12	87
Syn-1	2.608	0.282	0.29	0.25	20
VDH-8003	3.029	0.503	0.80**	0.10	83
Akamar	2.871	1.073	1.12**	0.29*	75
Consul	2.968	1.177	1.19**	0.29*	77
Okapi	2.917	0.749	1.01**	0.10	88
L-I	2.936	1.092	1.20**	0.17	85
Olera	3.400	1.081	1.18**	0.19	84
Reg x Cob	3.184	1.428	1.29**	0.38	75
Hyola-42	2.597	0.874	0.55	0.73	23
SLM-046	3.171	1.060	1.12**	0.26	78

*Significant at 5% level
**Significant at 1% level

Stability parameters

In the present investigation, the regression of varietal average yield on the environmental index resulted in regression coefficients ranging from 0.29 (Syn-1) to 1.35 (DP-94-8). Four genotypes viz., Symbol, Fornax, Parade and Okapi had b-values close to unity with average response and low deviation from regression, hence suitable for wider range of environments. Six entries viz., Eurol, Hansen, Colvert, Mohican, Orkan and VDH-8003 had b<1 and they had also least S^2d indicating their stability for poor agronomic conditions. Whereas an other set of 6 genotypes including, Orient, Cocktail, Alice, Olera, Reg x Cob and SLM-046 had significant regression coefficients greater than unity (b>1), above average performance and minimum deviations from regression indicated that these genotypes are suitable for favourable environments. A further perusal of the Table 4 indicated that all the genotypes except Syn-1 and Hyola-42, possessed significant coefficients indicating their response to environmental changes predictable and feasible for the trait under study. As reported by Singh & Chaudhry (1979), if the S^2d is non significant from zero, performance of a genotype for a given environment may be predicted and *vice versa*. In this study, three genotypes GWC, Licord and Consul gave above average performance but deviation from regression was significant hence the performance of these genotypes seems to be unpredictable. The coefficient of determination (R^2) measures the proportion of the variation in the mean yield of a genotype which is accounted for by the fitted model (Singh & Chaudhry, 1979). Estimates of coefficient of determination for Syn-I and Hyola-42 were 20 and 23, respectively indicating that this model is not fit for these genotypes.

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