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Full Length Research Paper

Stability analysis of canola (*Brassica napus)* genotypes in Pakistan.

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Thirty canola type promising genotypes of *Brassica napus* were evaluated for their stability at 10 different locations across Pakistan during 2009-10. Combined analysis of variance revealed highly significant genotype x environment (G x E) interaction .The mean seed yield (t ha $^{-1}$) of these ten locations, ranged from 0.868 to 1.661 t ha^{-1}. Seventeen genotypes produced more seed yield as compared to overall mean value i e. 1.353 t ha^{-1}. The genotype Hyola 471 CL out yielded and produced 1.661t ha^{-1}seed yield followed by genotype Hyola-432 and Hyola-76 with seed yield of 1.647 and 1.625 t ha^{-1}, respectively. NIFA, Peshawer and NARC, Islamabad were identified as best locations with an average seed yield of 2.562 and 2.545 t ha^{-1} followed by Dera Ismail Khan (2.459 t ha^{-1}). The regression coefficient (b_i) of genotypes ranged from 0.80 to 1.32. Genotype Shiralee was the most stable and well adaptive genotype because it showed above average performance (1.454 t ha^{-1}), b_{i-} value nearer to unity (b_i = 1.02) and less value of deviation from regression (0.07), therefore, this genotype has wider adaptability and recommended for cultivation on diverse environments across the country. The genotype Hyola-471CL, Hyola-76, OMEGA-II and SPS-N20 were suitable for favorable environments and the genotypes RBN-03255, RBN-03046, OMEGA-III, and Hyola-433 were suitable for unfavorable environments.

Keywords: *Brassica napus,* stability analysis, genotype x environment interaction, Pakistan

INTRODUCTION

Brassica napus is one of the popular oilseed crops in the Pakistan. Brassica breeders are devoting their efforts to develop new productive stable canola varieties in Pakistan because the use of adapted genotypes for general cultivation over wide range of environmental conditions helps in achieving stabilization in crop production over locations and years. Some genotypes may perform well in some environment but no so well in other (Dhillon *et a*l, 1999).This variation is due to genotype x environment (G x E) interaction Yan *et al.*,(2007) defined the ideal cultivar as one that would be with high seed yield and high stability when evaluated across different environments.. A number of investigators like Finlay and Wilkinson, 1963; Ali *et al* 2001 & 2003; Ahmed *et al* 1996; khan *et al*,1998 described the importance of (G x E) interaction in stability analysis. Many models have been developed to measure the stability parameters and partitioning of variation due to (G x E) interaction (Finlay and Wilkinson, 1963; Eberhart and Russel, 1966; Freeman and Perkins, 1971; Shulka, 1972). The model proposed by Eberhart and Russel (1966) is more commonly used for stability studies in different crops. Yao and Xu (1994) studied adaptability and yield

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stability of rapeseed varieties and revealed that variety x year interaction was greater than variety x location interaction. Hussain *et al*., (1996) evaluated 11 rapeseed varieties in three seasons for stability of seed yield and found four varieties viz., M-27, T-9, YST-151 and RSK-7 as stable over the years. Rashid *et al*., (2000) indicated that heterogeneity of regression was highly significant and genotypes KS-74 and CV-3 were relatively stable having b value near to 1 and low deviation from regression. They further reported that regression coefficient is the most useful stability statistics for selection of stable genotypes in mustard. Ali *et al*., (2002) evaluated 12 winter type rapeseed varieties of *Brassica napus* at 10 location and found top yielding genotype Shiralee, SLM-046 and Wotan as stable cultivars for grain yield because they have slope near to unity and non significant deviation from regression. Javid Far *et al* (2004) studied 24 winter canola (*Brassica napus*) genotypes for two years in 9 locations. He reported non significant genotype x year interaction while significant genotype x environment (linear) interaction effects. He declared SLM046 and Parade with 3.43 and 3.34 t ha $^{-1}$ of grain yield respectively as well adaptable genotypes in all the environments. Escobar *et al* (2011) studied genotype x environment (Gx E) interaction in canola (*Brassica napus*) cultivars in Chile and reported that G x E interaction was significant for seed yield in many locations in one cropping season. He also reported Monalisa hybrid as the high yielder and most stable cultivar across all environments. Like in many other countries, in Pakistan, before a variety is released for general cultivation, at least 2 years performance tests in different environment is required Pakistan has diverse environmental conditions with respect to temperature, rainfall and soil texture. Stability analysis is an important tool for plant breeders in predicting response of various genotypes over changing environments. The present investigations provide an opportunity to the breeders of Pakistan to evaluate their pipeline Brassica varieties in a wide range of agro ecological zones of the country. It will also help the scientists to identify superior varieties with wider adaptability and recommended suitable genotypes for general cultivation in the country.

MATERIAL METHODS

Thirty genotypes of rapeseed (*B. napus*) were evaluated for yield performance at ten locations across Pakistan during Rabi 2009-10. The name and sources of these genotypes are listed in Table 1.

The genotypes were sown under irrigated conditions of the following ten locations across Pakistan.

The experiment was conduced in randomized complete block design with 4 replications. Plot size of 4 rows of 5 meter length with 30 cm row spacing was used. Experiments were sown at each site with recommended seed rate. Fertilizer @ 90N: 60 $P_2 O_5$ Kg/ha were applied and incorporated at the time of seed bed preparation. Irrigation, weed and pest control measure were applied whenever required. Seed yield per / plot was estimated by harvesting and threshing the 2-4 rows from each plot and converted into kg/ha.

A combined analysis of variance over location was computed assuming replications and locations effects as random and genotypes were considered as fixed variable (Steel and Torrie, 1980). The stability parameters;

1. **Regression coefficient (b_i):** This is a regression performance of each genotype in different locations calculating means over all the genotypes and estimated by following Sing and Chaudhary,1979.
2. **Mean square deviation from regression (S^2d_i):** This was calculated for each genotype following Eberhart and Russell Model (1966).A genotype, which has high mean yield, regression coefficient (b_i) close to unity and deviation from regression (S^2d_i) near to zero, is defined as a stable genotype.

RESULTS AND DISCUSSION

Differences among genotypes for seed yield (t ha $^{-1}$) were significant at all the locations except at Kohat, where the differences were non significant (Table 4).Highest average seed yield of 2.562 and 2.545 t ha $^{-1}$ NIFA, Peshawar and NARC,Islamabad locations respectively and closely followed by DIK (2.459 t ha $^{-1}$). Pioneer farms, Bahawalpur and Quetta were the lowest yielding locations with an average seed yield of 0.374, 0.612 and 0.632 t ha $^{-1}$ respectively. The highest seed yield of 3.491 and 3.488 t ha $^{-1}$ was obtained by OMEGA-II and Hyola 76 respectively at NARC, Islamabad followed by Hyola 471 CL (3.375 t ha $^{-1}$) at NIFA, Peshawar. The highest yielding genotype Hyola 471 CL was also highest at NIFA, Peshawar (3.375 t ha $^{-1}$) and DIK (3.111 t ha $^{-1}$) locations. The mean seed yield (t ha $^{-1}$) of these ten locations, ranged from 0.868 to 1.661 t ha^{-1}. Seventeen genotypes produced more seed yield as compared to overall mean value i e. 1.353 t ha^{-1}The genotype Hyola 471 CL out yielded and produced 1.661t ha^{-1}seed yield followed by genotype Hyola-432 and Hyola-76 with seed yield of 1.647 and 1.625 t ha^{-1}, respectively. The genotype DCH-002 was low yielding and produced only mean seed yield 0.868 t ha $^{-1}$.

The seed yield data (kg/ha) of 30 *B.napus* genotypes from ten locations was pooled and analysis of variance combined over locations was performed. Table 3 showing combined analysis revealed that there were significant differences between genotypes, locations and their interaction (G x E).Kirishnanand *et al*, (1997); Ravi *et al*., (1997); Dhillon *et al*., (1999) Wani.,1992 and Ali *et al*., (2002) also reported significant Gx E interaction for yield in both Indian rapeseed and mustard .

The significant G x E interaction indicated that seed yield ranking of genotypes changed over the locations due to

Table 1. Name and source of rapeseed genotypes evaluated during Rabi 2009-10.

Sr. No	Name	Source
1	Hyola-50	ICI Pakistan Seeds Limited, Lahore
2	RBN-03046	Oilseeds Research Institute, Faisalabad
3	MK-515	Emkay Corporation, Lahore
4	CRH 60/08	Oilseeds Research Program, NARC, Islamabad
5	SPS-N-20	Oilseeds Research Program, NARC, Islamabad
6	MK-516	Emkay Corporation, Lahore
7	Hyola-76	ICI Pakistan Seeds Limited, Lahore
8	CRH35/08	Oilseeds Research Program, NARC, Islamabad
9	MK-517	Emkay Corporation, Lahore wal
10	OMEGA-III	Auriga Seeds Corporation, Lahore
11	BURAQ-101	Suncrop Pesticide, Multan
12	KN 120-35	Oilseeds Research Station, Khanpur (Rahim Yar Khan)
13	DCH-001	Dagha Corporation Karachi
14	AGAMAX	Seethi Seed Company, Sahiwal
15	RBN-03075	Oilseeds Research Institute, Faisalabad
16	Hyola-432	ICI Pakistan Seeds Limited, Lahore
17	CRH-09/08	Oilseeds Research Program, NARC, Islamabad
18	BURAQ-202	Suncrop Pesticide, Multan
19	MK-519	Emkay Corporation, Lahore
20	8CBN-021	Barani Agric. Research Institute, Chakwal
21	Hyola-471 CL	ICI Pakistan Seeds Limited, Lahore
22	RBN-03255	Oilseeds Research Institute, Faisalabad
23	TRAPPER	Seethi Seed Company, Sahiwal
24	OMEGA-II	Auriga Seeds Corporation, Lahore
25	DCH-002	Dagha Corporation Karachi
26	ZR-01	King Seed Corporation, Sadiqabad
27	SHIRALEE	Oilseeds Research Program, NARC, Islamabad
28	Hyola-433	ICI Pakistan Seeds Limited, Lahore
29	MK-520	Emkay Corporation, Lahore
30	SPS-N7	Oilseeds Research Program, NARC, Islamabad

Table 2. Name of Institutes/Stations where experiment was conducted during 2009-10.

S.	Name of Institutes/Stations	Abbreviatio	Sowing Dates
1	National Agricultural Research Centre, Islamabad	NARC	17-10-2009
2	Nuclear Institute for Food and Agriculture, Tarnab, Peshawar	NIFA	-
3	Oilseed Research Institute, AARI, Faisalabad	F-Abad	15-10-2009
4	Regional Agricultural Research Institute, Bahawalpur	B-Pur	-
5	Agricultural Research Station, Khanpur (Rahim Yar Khan)	K-Pur	16-10-2009
6	SBB Agric Res. Station Benazir Bhutto Abad, Sakrand, Sindh	Sakrand	11-11-2009
7	Agricultural Research Institute, Dera Ismail Khan	DIK	10-10-2009
8	Barani Agricultural Research Station, Kohat	Kohat	14-10-2009
9	Agricultural Research Institute, Sariab, Quetta	Quetta	-
10	Pioneer Pak Seed, Ltd., Johar Town, Lahore	Pioneer	27-10-2009

Table 3. Combined analysis of variance for seed yield (t ha^{-1}) of thirty B. napus genotypes at ten locations during 2009-10			
Source of variation	**Degree of freedom**	**Mean Square**	**F. value**
Location (E)	9	256.337	320.017**
Error	30	0.801	-
Genotypes (G)	29	1.584	2.5063**
G x E	261	0.632	6.7317**
Error (Pool)	870	0.094	-
Total	1199		

** Significant differences at 1 percent (p < 0.01)

Table 4. Mean performance of thirty *Brassica napus* genotypes for seed yield (t/ha) and stability analysis from ten locations during 2009-10.												
Genotype Name	**NARC**	**FSD**	**Pioneer**	**B-Pur**	**K-Pur**	**NIFA**	**DIK**	**Kohat**	**Sakrand**	**Quetta**	**Mean**	**b_i**	**S^2d_i**
Hyola-471CL	3.015	1.761	0.477	0.944	2.083	3.375	3.111	0.550	0.875	0.420	1.661	**1.32****	0.081
Hyola-432	2.555	1.694	0.452	0.917	1.708	3.208	2.894	1.003	1.234	0.809	1.647	1.07	0.043
Hyola-76	3.488	1.789	0.477	0.389	1.917	3.146	2.333	0.998	1.046	0.669	1.625	1.22 **	0.105
Hyola-50	3.012	1.606	0.527	1.111	2.292	2.625	2.778	0.805	0.907	0.476	1.614	1.08 **	0.105
OMEGA-III	2.030	1.722	0.298	0.833	1.333	2.750	2.972	0.990	1.030	0.679	1.464	0.97	0.093
Shiralee	**2.693**	**1.789**	**0.261**	**0.500**	**1.833**	**2.313**	**2.667**	**0.902**	**0.590**	**0.995**	**1.454**	**1.02**	**0.074**
8CBN-021	2.825	1.483	0.345	0.617	1.833	2.250	2.750	0.978	0.988	0.435	1.450	1.04	0.062
RBN-03255	2.070	1.594	0.472	1.194	1.833	2.771	2.389	0.833	0.654	0.560	1.437	0.88 **	0.092
MK-516	2.320	1.250	0.689	0.333	1.167	3.354	2.694	0.789	0.856	0.878	1.433	1.10 **	0.125
RBN-03075	2.770	1.633	0.315	0.833	2.208	2.479	2.611	0.619	0.314	0.549	1.433	1.09	0.117
RBN-03046	2.439	1.411	0.662	1.083	1.625	2.250	2.389	0.789	0.745	0.880	1.427	0.80 **	0.029
TRAPPER	2.285	1.328	0.286	0.861	1.875	2.813	2.561	1.214	0.409	0.481	1.411	1.03	0.079
OMEGA-II	3.491	0.972	0.419	0.417	1.917	2.354	2.361	0.986	0.499	0.520	1.394	1.16 **	0.162
KN 120-35	2.192	1.511	0.423	0.555	1.583	2.521	2.944	0.781	0.704	0.616	1.383	1.02	0.055
Hyola-433	1.608	1.594	0.389	0.528	0.958	3.042	2.833	0.858	1.060	0.934	1.380	0.92	0.208
SPS-N-20	3.037	0.972	0.267	0.472	1.500	2.771	2.472	0.825	0.815	0.637	1.377	1.15 **	0.041
MK-515	2.486	1.250	0.451	0.417	1.167	3.083	2.278	1.465	0.592	0.456	1.365	1.05	0.094
AGAMAX	2.230	1.311	0.305	0.350	1.458	2.771	2.611	0.924	0.540	0.825	1.333	1.04	0.037
MK-519	2.426	1.444	0.532	0.625	1.958	2.396	1.806	0.990	0.490	0.469	1.314	0.85 **	0.095
CRH35/08	3.029	1.417	0.171	0.833	1.083	2.104	2.472	0.885	0.602	0.410	1.301	1.04	0.081**
SPS-N7	3.163	1.567	0.361	0.500	1.000	2.125	2.056	0.646	0.942	0.596	1.296	0.98 *	0.128
CRH-09/08	2.048	1.333	0.170	0.611	1.583	2.146	2.639	0.813	1.072	0.483	1.290	0.89 **	0.071 **
MK-517	2.858	0.944	0.376	0.222	0.833	2.479	2.028	0.998	0.804	0.719	1.226	0.99	0.097

Table 4. Continue

BURAQ-101	2.214	1.217	0.268	0.694	0.792	2.688	2.222	1.103	0.293	0.722	1.221	0.95	0.075
CRH 60/08	2.267	1.306	0.270	0.528	1.500	2.104	2.000	0.858	0.623	0.635	1.209	0.83 **	0.017
ZR-01	3.110	0.929	0.230	0.444	0.583	2.104	2.278	0.791	0.545	0.863	1.188	1.02	0.155 *
BURAQ-202	1.748	1.022	0.442	0.500	0.292	2.604	2.500	0.986	0.775	0.581	1.145	0.86 **	0.176
DCH-001	2.539	1.122	0.350	0.378	0.208	2.104	2.444	0.919	0.475	0.760	1.130	0.95	0.157
MK-520	1.503	1.350	0.272	0.472	1.042	2.479	2.139	0.742	0.543	0.447	1.099	0.82 **	0.072
DCH-002	2.899	0.139	0.267	0.194	0.292	1.646	1.528	0.927	0.337	0.446	0.868	0.86 **	0.294
Average	**2.545**	**1.349**	**0.374**	**0.612**	**1.382**	**2.562**	**2.459**	**0.899**	**0.712**	**0.632**	**1.353**	**-**	**-**
LSD 5 %	240	105	257	70	163	637	861	N.S	74	469	-	-	-
CV %	6.69	9.98	48.0	8.92	8.43	17.67	20.9	24.9	6.19	5.65	-	-	-

existence of environmental effect on their yield performance. Thus stability parameters from seed yield were calculated for 30 *Brassica napus* genotypes. The regression coefficient (b_i) of *Brassica napus* genotypes ranged from 0.80 to 1.32. The genotype Hyola-471CL had the highest regression coefficient (b_i =1.32) followed by genotype Hyola-76 (b_i =1.22), OMEGA-II (b_i =1.16) and SPS-N20 (b_i =1.15). The regression coefficient greater than unity (b_i>1.0) indicated that these entries are suitable for favorable environments. The genotypes RBN-03255 (b_i=0.88), CRH-09/08 (b_i=0.89), DCH-002 (b_i=0.86), OMEGA-III (b_i=0.97), RBN-03046 (b_i=0.80) and Hyola-433 (b_i=0.92) MK-519 (b_i=0.85), SPS-N7 (b_i=0.98), CRH 60/08 (b_i=0.83), BURAQ-202 (b_i=0.86), MK-520 (b_i=0.82) and DCH-002 (b_i=0.86)had regression coefficient less than unity (b_i<1.0) indicating that these entries are suitable for unfavorable environments. The genotypes Shiralee (b_i = 1.02) and KN 120-35 (b_i = 1.02) had regression coefficient close to unity and low deviation from regression indicated that these are the most stable and well adaptive entries and suitable for commercial cultivation across the country. Similar results have been reported by Ali *et al*., (2002).

CONCLUSION

It is concluded that seed yield in canola *(Brassica napus*) grown in Pakistan is strongly influenced by genotype x environment interaction of the total variation. According to the results based on mean of grain yield, coefficient of regression and deviation from regression, **Shiralee** is the genotype with well adaptability in all the environments of Pakistan. The conclusion is based on only one year of experimentation, so the results could be changed if more data were included covering a longer period of time. Hence, the study was carried out in many locations in order to provide validity to the results.

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