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Stability analysis for yield and its contributing traits in Brown *sarson* (*Brassica rapa* L.) under Kashmir conditions in India

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Abstract

Twelve elite genotypes of Brown sarson (*Brassica rapa* L.) including two checks viz., KS-101 and SBS-1 were evaluated during *rabi* 2011-12 across three random environments for stability performance in yield, yield contributing characters and oil content as per Eberhart and Russell model. Analysis of variance revealed that the genotypes exhibited highly significant genetic variability for all the traits viz., primary branches plant^{-1}, length of main raceme (cm), number of siliquae on main raceme, number of siliquae plant^{-1}, number of seeds siliqua^{-1}, 1000-seed weight (g), seed yield plant^{-1} (g) and oil content (%). The mean squares due to environments were also significant for all the traits indicating the environments selected were random and were different in agro-climatic conditions. G x E interactions were observed to be significant for all the traits. Based on the stability parameter of Eberhart and Russel model, SKBR-11 was considered as stable and average responsive to the environments for yield and most of the component traits.

Key words: *Brown sarson, Stability, Eberhart and Russell model, G X E Interaction*

Introduction

Brown sarson (*Brassica rapa* L.) belongs to the *Cruciferae* (*Brassicaceae*) family (A genome, n=10). It is native throughout Europe, Russia, Central Asia and the Near East with Europe proposed as one of the centres of origin (Prakash and Hinata, 1980). The Asian types comprise of three ecotypes brown sarson, yellow sarson and toria. Brown sarson includes both *lotni* (self-incompatible) and *tora* (self-compatible) types. The ecotypes yellow sarson and toria are derived from brown sarson, the former being the mutant for quality and latter being the result of selection (Hinata and Prakash, 1984). Brown sarson is one of the most important oleiferous Brassicas cultivated in the north western regions of India. It is either grown as a pure crop or as a mixture with other major *rabi* crops in mostly rainfed areas of the country. In Kashmir valley and high altitude regions of Jammu divisions brown sarson is the only edible oilseed crop being cultivated during *rabi* season. This is the only crop of the rapeseed-mustard group which fits well in the oilseed – paddy rotation prevailing in the valley of Kashmir. In the state of Jammu and Kashmir brown sarson is the major oilseed crop cultivated on an area of 0.65 lakh hectares with a production of 4.95 lakh quintals and an average productivity of 7.6 q ha^{-1} (Anonymous, 2010).

Use of diverse cultivars with high yielding ability, high oil content and early maturity would enable farmers to achieve higher production and consequently change the edible-oilseed scenario of the state. Besides, yield potential and early maturity, the variety should also possess stability in its performance over a range of environments. Knowledge on the interaction and stability is foremost in breeding varieties for wider adaptation in diverse agro-climatic conditions. The aim of a breeding programme should be to develop genotype that can withstand unpredictable transient environmental fluctuations. To identify the stable genotypes having adaptability over a wide range of agro-climatic conditions is of major significance in crop improvement. With the statistical techniques developed to estimate stability parameters (Finlay and Wilkinson, 1963; Eberhart and Russel, 1966) it is possible to detect genotypic differences for wide adaptability in crop improvement. In the present investigation, an attempt has been made to study the stability of 12 genotypes over three environments in brown sarson.

Materials and Methods

The present study was undertaken at three diverse locations representing northern, southern and central agro-climatic regions of Kashmir valley during *rabi* 2011-2012. The random locations were: Experimental Farm, Division of Plant Breeding & Genetics SKUAST-Kashmir, Shalimar, Srinagar (E-I), Experimental Farm, Mountain Research Centre for Field Crops, Khudwani, Anantnag (E-II) and Experimental Farm, Organic Farming Research Centre, Wadura, Baramulla (E-III). Srinagar lies between 34.08^0 N latitude and 74.51^0 E longitude and is located 1730 meters above mean sea level with 710 mm average rainfall. Anantnag lies between 33.73^0 N latitude and 75.15^0 E longitude and is located 1601 meters above mean sea level with 800.9 mm average rainfall. Baramulla lies between 34.30^0 N latitude and 73.47^0 E longitude, and is located 1581 meters above mean sea level with 1200 mm average rainfall. All the three environments fall in temperate zone and experience almost same temperature with slight differences.

Twelve diverse genotypes of brown sarson (*Brassica rapa* L.) viz. SKBR-4, SKBR-7, SKBR-11, SKBR-16, SKBR-20, SKBR-22, SKBR-24, SKBR-26, SKBR-27, SKBR-28 including two checks i.e., KS-101 and Shalimar Brown Sarson-1 (SBS-1) were evaluated for yield and yield contributing characters in a Complete Randomized Block Design with three replications at each location. Each genotype was grown in a 3-row experimental plot of 3 metre length with inter and intra row spacing of 30 and 10 cm, respectively. The experimental fields were well prepared and standard recommended package of practices were followed to raise a good crop.

A Material Transfer Agreement (MTA) was signed between ITK Germany and SKUAST-K, followed by hybridization programme between the introduced material and the local material to test the adaptability under local conditions and introgression of newer genes. The progenies were carried in further breeding programmes and some of the outstanding progenies coded as SKBR (Sher-e-kashmir *Brassica rapa*) were used in the present study. Each genotype was grown in a 3-row experimental plot of 3 metre length with inter and intra row spacing of 30 and 10 cm, respectively. The experimental fields were well prepared and standard recommended package of practices were followed to raise a good crop. Observations on days to 50% flowering, plant height (cm), primary branches plant^{-1}, length of main raceme (cm), number of siliquae on main raceme, number of siliquae plant^{-1}, number of seeds siliqua^{-1}, days to maturity, 1000-seed weight (g), seed yield plant^{-1} (g) and oil content (%) were recorded on ten randomly selected competitive plants from each experimental plot in each replication for all traits except maturity where the data would be recorded on whole plot basis.

The phenotypic stability of twelve genotypes studied in three different environmental conditions was worked out following the linear model proposed by Eberhart and Russell (1966). For analyzing the results window stat software was used.

Results and discussion

A variety can be considered stable across environments if it has high mean yield, unit regression and least deviation around the regression slope (Eberhart and Russell, 1966). Although there are many stability parameters, Eberhart and Russell (1966) model's parameter S^2d_i appeared to be very important. Since the variance of S^2d_i is a function of number of environments hence several environments with minimum replications per environment are advocated to be necessary to obtain reliable estimates of S^2d_i. Analysis of variance revealed that the genotypes possessed highly significant genetic variability for all the traits viz., primary branches plant^{-1}, length of main raceme (cm), number of siliquae on main raceme, number of siliquae plant^{-1}, number of seeds siliqua^{-1}, 1000-seed weight (g), seed yield plant^{-1} (g) and oil content (%). The mean squares due to environments were also significant for all the traits indicating the environments selected were random and were different in agro-climatic conditions.

Interaction of genotypes with the environment (G x E) were observed to be significant for all the traits, thereby revealing that genotypes performed differently for traits under study at different locations (Table 1). Partitioning of environment + (G x E) interaction into Environment (linear), G x E (linear) and pooled deviation revealed that mean square due to environment (linear) was significant for all traits, which confirmed that significant differences existed between environments and had shown considerable influence on expression of traits under study. Similarly, G x E (linear) was observed to be significant for all traits revealing that the behavior of the genotypes for these traits is predictable over environments and this has resulted from the linear function of the environmental component. The mean squares due to pooled deviation (non-linear) were significant for all the traits, revealing that the non-liner component was important for these traits which contributed to total G x E interaction. Thus the genotypes differed considerably for stability for the traits under investigation over the environments.

Significant mean squares have been reported for most the traits in ten genotypes of yellow sarson (*Brassica campestris* L. var yellow sarson) evaluated at three locations for stability of seven characters by Dharmendra and Mishra (2003) and Chauhan *et al*. (2010) and Yadava *et al*. (2010) in Indian mustard. For genotype-environment interaction significant mean squares have been reported by Naazar *et al.* (2003) in twenty five elite genotypes of winter rapeseed through regression analysis for their phenotypic stability in seven cold and six mild cold regions of Iran. Brar *et al.* (2007) and Sah *et al.* (2009) have concluded similar results in Indian mustard. The variance due to genotype x environment (linear), genotype (G), environments (E) were found significant for various traits by Dharmendra and Mishra (2003). Both linear and non linear components of genotype x environment interaction were reported to be significant by Quddus *et al*. (1991) in ten genotypes of *Brassica campestris* for five yield components grown over six years. The variance due to genotypes x environments (linear) was found significant for various traits by Yadava *et al.* (2010). Significant

Table 1.Analysis of variance for stability of yield, yield contributing and quality traits in brown sarson (*Brassica rapa* L.) genotypes across random environments in the Kashmir valley.

Source of variation	d.f.	MEAN SQUARES							
		Primary branches plant^{-1}	Length of main raceme	Number of siliquae on main raceme	No. of siliquae plant^{-1}	No. of seeds siliqua^{-1}	Seed yield plant^{-1} (g)	1000-seed weight (g)	Oil content (%)
Genotypes	11	0.214**	39.830**	40.507**	109.817**	8.301**	0.911**	0.052**	5.429**
E + (G x E)	24	0.002**	0.226**	0.283**	0.304**	0.284**	0.002**	0.010**	0.144**
Environments	2	0.024**	2.547**	3.108**	3.438**	3.203**	0.027**	0.049**	1.572**
G x E	22	0.023*	0.015**	0.026*	0.019*	0.018*	0.010*	0.006**	0.015*
Environments (linear)	1	0.025**	5.022**	6.215**	6.877**	6.406**	0.048**	0.074**	3.144**
G x E (linear)	11	0.004*	0.026**	0.023*	0.045**	0.031**	0.012**	0.011**	0.025**
Pooled deviation	12	0.023*	0.076*	0.048*	0.057*	0.052*	0.039*	0.034*	0.059*
Pooled error	72	0.034	0.021	0.036	0.028	0.022	0.005	0.008	0.025

* Significant at p=0.05; ** Significant at p=0.01

Table 2 : Stability parameters for number of siliquae plant^{-1}, number of seeds siliqua^{-1}, 1000 seed weight (g), seed yield plant^{-1} (g) and oil content (%) in Brown Sarson (*Brassica rapa* L.) genotypes evaluated across three random environments

Genotype	Number of siliquae plant^{-1}			Number of seeds siliqua^{-1}			1000 seed weight (g)			Seed yield plant^{-1} (g)			Oil content (%)		
	Mean	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**
SKBR-4	222.1^{c}	1.45	0.037	18.68	1.46	0.002	3.12^{b}	0.60*	-0.009	6.36^{c}	0.87	0.001	40.09	1.20	0.021
SKBR-7	220.1	0.85	0.041	19.24^{b}	1.11	0.020	3.11^{c}	0.55*	-0.005	6.14	0.91	0.014	41.42^{b}	1.10*	0.017
SKBR-11	229.7^{a}	1.38	0.034	20.00^{a}	1.18	0.019	3.18^{a}	0.52*	-0.008	6.67^{a}	1.64	0.019	41.63^{a}	1.12*	0.007
SKBR-16	226.7^{b}	1.32	0.037	15.30	0.87	0.022	3.16	0.72	0.026*	6.55^{b}	1.09	0.002	40.94^{c}	1.21	0.016
SKBR-20	217.0	0.78	0.035	15.70	1.39	0.008	2.85	0.87	-0.005	5.48	0.87	0.005	39.67	0.99	0.019
SKBR-22	215.7	0.95	0.043	18.94^{c}	0.91	0.021	3.12	0.62	-0.008	5.67	1.46	0.012	40.22	0.83	0.020
SKBR-24	210.2	0.78	0.038	16.06	0.77	0.017	2.88	0.80	-0.004	5.40	0.76	0.004	38.67	0.74	0.008
SKBR-26	209.3	0.68	0.032	14.70	1.08	0.021	2.71	0.85	0.002	4.35	0.95	0.007	37.47	0.87	0.016
SKBR-27	212.7	0.98	0.046	15.88	0.84	0.019	2.86	0.52*	0.001	4.83	0.74	0.003	38.04	0.83	0.012
SKBR-28	216.0	1.05	0.041	16.96	0.87	0.020	3.04	0.60*	0.004	5.10	1.02	0.002	39.70	0.72	0.020
KS-101#	210.1	1.08	0.044	17.06	0.75	0.015	3.00	0.61	0.002	3.28	0.82	0.001	37.91	0.59	0.025
SBS-1#	218.0	0.75	0.039	17.36	0.77	0.017	2.98	0.62	-0.008	3.23	0.84	0.002	38.10	0.95	0.029
Mean	**217.3**	-	-	**17.16**	-	-	**3.01**	-	-	**5.25**	-		**39.48**	-	-
SE(m)±	**0.1**	-	-	**0.049**	-	-	**0.013**	-	-	**0.003**	-	-	**0.044**	-	-
SE(b)±	-	**0.1**	-	-	**0.095**	-	-	**0.208**	-	-	**0.118**	-	-	**0.121**	-

Check varieties, * Significant at p=0.05; ** Significant at p=0.01. (a = First rank, b = Second rank, c = Third rank)

mean squares for pooled deviation (non-linear) regarding various traits have been reported by Jakhar and Yadav (2010) in thirty genotypes of taramira over three environments for analysis of stability parameters with respect to yield and associated characters.

In the present investigation, estimation of stability parameters for twelve brown sarson genotypes revealed non-significant estimates of deviation from regression (S^2d_i) for all traits, however, some genotypes displayed significant mean square deviation from regression (S^2d_i) such as SKBR-16 for 1000 seed weight. The genotypes showing non-significant mean square deviation (S^2d_i) from the regression indicated that non-linear component (heterogeneity from regression) was equal to zero. Hence, the performance of these genotypes for a given environment could be predicted. Accordingly, a genotype whose performance could be predicted (i.e., $S^2d_i = 0$) was classified to be stable.

The significant deviation from unity for linear regression was reported in various traits with respect to genotypes such as SKBR-11 (primary branches plant^{-1}); SKBR-11 (number of siliquae on main raceme); SKBR-4, SKBR-27 and SKBR-28 (1000-seed weight) and SKBR-7 and SKBR-11 (oil content). Significant and greater than 1 was found in SKBR-11 for days to 50 % flowering, number of siliquae on main raceme and oil content. Rest of the genotypes showing non-significant regression coefficient (b_i) value and deviation from the regression (S^2d_i) were average in stability and were either favourably or poorly adapted to the environments (Table-2). Accordingly, the promising genotypes having maximum number of primary branches plant^{-1} were SKBR-11 and SKBR-7, maximum length of main raceme (cm) were SKBR-11 and SKBR-7. For the trait number of siliquae on main raceme the promising genotypes were SKBR-16 and SKBR-7, for number of siliquae plant^{-1} the promising genotypes were SKBR-11 and SKBR-16, for number of seeds siliqua^{-1} genotypes SKBR-11, SKBR-7 and SKBR-22 were found promising. For seed yield plant^{-1} (g) genotypes SKBR-11, SKBR-16 and SKBR-4 were found to have the highest yield. Genotypes SKBR-11 and SKBR-16 had the maximum 1000 seed weight (g). For oil content (%) promising genotypes found were SKBR-11, SKBR-7, SKBR-16 and SKBR-4. Considering their mean performance and the average stability into consideration, it could be derived that SKBR-26 was poorly adapted, while SKBR-11 was well adapted to all the environments. Stability of genotypes for the various yield and yield related traits such as siliquae plant^{-1}, seed weight, seed siliquae^{-1} and others revealed that the genotypes SKBR-11, SKBR-7, and SKBR-16 were having higher productivity and were average in stability across all the environments. Highest mean performance for seed yield plant^{-1} was observed to be higher in SKBR-11 (6.67 g) which was surpassing both the checks KS-101 (3.28 g) and SBS-1 (3.23 g). Stability parameters for oil content revealed that the genotypes SKBR-7 and SKBR-11 were having 25% more oil content as compared to the check varieties.

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