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Genetic Variability among Brown Sarson (*Brassica rapa* L.) Genotypes for Yield-Related Trait-Oil Content

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ABSTRACT

Background and Objective: Brown sarson is gaining wide acceptance because of its adaptability for both rainfed as well as irrigated areas and suitability for sole as well as mixed cropping. Being a major rabi (winter season) oilseed crop, it has greater potential to increase the availability of edible oil from domestic production. In this background, the present investigation was carried out to generate information on the adaptive potential and stability parameters of ten diverse genotypes of brown sarson for varietal selection and stability in their performance to characterize the nature of genotype' environment for various yield and yield-related traits at various locations. **Materials and Methods:** The basic material for the study comprised 10 genotypes of brown sarson (*Brassica rapa* L.) grown in a 3-row experimental plot of 3 m length with inter and intra row spacing of 30 and 10 cm, respectively. The qualitative data generated through participatory rural appraisal (PRA) was analyzed by using a χ^2-test. The data generated from replicated grandmother trials were analyzed through ANOVA. **Results:** Analysis revealed that all genotypes possessed significant differences in oil content. Mean squares due to GXE interaction were significant for the trait. The component analysis of the environment (GXE) revealed significant mean squares for the trait. Mean squares of linear and non-linear components revealed that environments (linear) were significant for oil content and the significant mean squares for E+(GXE) for the trait arose due to environments (linear) and linear response of the regression of the cultivars to the environment. **Conclusion:** Genotypes possessed significant variability for oil quality and oil content and could be used as parental stocks for crop improvement programmes.

KEYWORDS

Brown sarson, *Brassica rapa*, oilseed crop, stability, genotype, GXE interaction, eberhart and russell model

INTRODUCTION

Oilseeds are the most ancient crops domesticated by mankind. Oil-producing crops currently occupy about 10% of global arable land and are second only to carbohydrate crops in terms of their importance

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as providers of calories for both humans and their livestock. During 2009-10, about 6.18 million hectares were put under rapeseed-mustard crop in the country with a production of 7.36 million tones giving the crop productivity of 11.90 quintals per ha[1]. India holds a premier position in the rapeseed-mustard economy of the world with 2nd and 3rd rank in area and production, respectively. It is the third-largest rapeseed-mustard producer in the world after China and Canada with 12% of the world's total production[2]. It is grown on an area of 5.8 m ha with a production of 6.8 mt and average productivity of 1.17 t ha^{-1}[3]. This crop accounts for nearly one-third of the oil produced in India, making it the country's key edible oilseed crop after groundnut and soybean[4]. This group of oilseed crops is gaining wide acceptance because of its adaptability for both rainfed as well as irrigated areas and suitability for sole as well as mixed cropping. Being a major rabi (winter season) oilseed crop, it has greater potential to increase the availability of edible oil from domestic production.

In the state of Jammu and Kashmir, brown sarson is the major oilseed crop cultivated on a large scale. During the year 2012-13, the crop was grown on an area of 0.67 lakh ha with a production of 5.32 lakh quintals and average productivity of 7.94 quintals per ha[5,6]. In addition to being cultivated under harsh wintery conditions, the constraints for achieving higher productivity of the crop include cultivation under sub-marginal conditions, non-availability of adequate quantities of quality seed together with low adoption of management practices recommended for realizing higher yields. To achieve higher production and consequently change the edible oilseed scenario of the state, it is imperative to develop improved varieties with high yielding ability, high oil content and early maturity. Besides yield potential, the variety should also possess stability in its performance over a range of environments. Knowledge of the interaction and stability is foremost in breeding varieties for wider adaptation in adverse agro-climatic conditions. The aim of the breeding program should be to develop genotypes that can withstand unpredictable transient environmental fluctuations.

MATERIALS AND METHODS

Study area: The study was conducted during rabi 2013-14 in three districts of Kashmir valley viz., Anantnag, Pulwama and Kulgam. In each district, two locations were selected to lay out the trials.

Experimental material used: The basic material for the study comprised 10 genotypes of brown sarson (*Brassica rapa* L.) and each genotype was grown in a 3-row experimental plot of 3 m length with inter and intra row spacing of 30 and 10 cm, respectively. The genotypes were evaluated using Randomized Complete Block Design (RCBD) with three replications across three random environments. The experimental fields were well prepared and all the recommended packages were adopted to raise a good crop.

Quantitative data: The data for quality traits were recorded from ten competitive plants from each replication to study stability performance over six random environments. Each selected plant was taken at random from each experimental plot in replication and tagged for recording bio-metrical observations.

Oil content (%): Oil content was determined by NIR (Model CROPS CAN 2000G/20d00B). Three samples were drawn randomly from each treatment and the average worked out for each replication.

Statistical procedures: The data generated from replicated grandmother trials were analyzed through ANOVA.

RESULTS

Table 1 analysis variance for the stability of oil content (%) in *Brassica rapa* var. brown sarson genotypes over environments. Mean squares arising due to genotypes×environments (G'E interaction) revealed significant differences for the trait, revealing that the genotypes were having, by and large, significant

Table 1: Analysis of variance for the stability of oil content (%) in *Brassica rapa* var. brown sarson genotypes over environments

Source of variations	df	Oil content (%)
Genotypes	9	5.139**
Environment+(genotypes×environment)	20	0.124**
Environment	2	1.241**
Genotypes×environment	18	0.013*
Environment (linear)	1	2.622**
Genotype×environment (linear)	9	0.021**
Pooled deviation (non-linear)	10	0.049*
Pooled error	54	0.023

*Significant at p = 0.05 and **Significant at p = 0.01

Table 2: Estimation of stability parameter (oil content) over different environments

	Oil content (%)		
Genotypes	Mean (X)	b_i	S^2d_i
KBS-69	40.08	1.20	0.022
KBS-33	41.40	1.11*	0.018
KBS-49	41.62	1.13*	0.006
KBS-38	40.93	1.21	0.015
KBS-5	40.20	0.81	0.021
KBS-40	37.98	0.73	0.007
KBS-F	37.27	0.85	0.014
KBS-28	39.72	0.72	0.020
KS-101	37.90	0.57	0.026
SBS-1	38.12	0.93	0.029
Mean	39.52	-	-
SE (m)	0.05	-	-
SE (b)	-	0.12	-

*Significant at p = 1.00

differential responses to the changing environments. Component analysis of the environments+ (genotype' environment) interaction E+(G'E)] was significant for the trait. Partitioning of this variation into linear and non-linear components revealed that the mean squares due to environments (linear) were highly significant for oil content. The non-linear component arising due to heterogeneity, measured as mean squares due to pooled deviation was significant for oil content (%). These significant mean squares revealed the presence of a non-linear response of the genotypes to the changing environments (stability performance). The significant mean squares for pooled deviation confirmed the contribution of the non-linear component to total G'E interaction. The genotypes differed in the stability for this trait making its prediction more difficult. However, comparing the magnitude of the linear component with that of the non-linear component of mean squares, it was observed that the linear component i.e., environment (L) and genotype' environment (L) was many times higher than the non-linear component (pooled deviation) for the trait. The trait displayed significant linear and non-linear components, however, the relative magnitude of the linear component was many times higher than that of the non-linear component. It revealed that the prediction of stability could be reliable, though it may get affected to some extent.

Table 2 depicts the estimation of oil content (%) and identification of suitable genotypes. The mean oil content of the genotypes across the environment ranged from 37.27 (KBS-F)-41.62% (KBS-49) with a mean oil content of 39.52%. The non-linear component (S^2d_i) was equal to zero making it possible to predict stability across the environments and was non-significant for all the genotypes. The linear regression coefficient (b_i) ranged between 0.57 (KS-101) and 1.21 (KBS-38) and was statistically non-significant except for the genotypes KBS-33 and KBS-49. The bi values were non-significant (b_i = 1) and thus, the genotypes having non-significant S^2d_i values were, by and large, average instability and were either poorly or well adapted to all these environments. The genotype KBS-49 with the highest oil content compared to the general mean and b_i value greater than 1 could be grouped as specially adapted to favourable environments.

DISCUSSION

Rapeseed and mustard is an economically important multipurpose oilseed crop globally and is one of the major contributors to the yellow revolution in India. In India, oilseed *Brassica* occupies a prominent position next to soybean. Brown sarson is a well-known oilseed crop cultivated during the rabi season in the Kashmir valley. The farmers allocate the available land resources for the cultivation of brown sarson as per their requirement, besides other major rabi crops, particularly oats. The crop is grown mostly on marginal lands under rainfed or limited irrigation conditions and several biotic as well as abiotic stresses are responsible for low yield. Thus, for increasing productivity, it is imperative to develop high yielding cultivars and genotypes suitable for cultivation under valley conditions that can perform better than the existing cultivars. Although some of the cultivars have been developed in the recent past, notably KOS-1, KOS-101 and SBS-1, further efforts are required to develop cultivars with high yield potential and greater stability to increase both the production and productivity.

One of the most important advances in biometrical genetics during the past several decades has been the investigation, elucidation and understanding of genotype×environment interaction. Climate data collected in this study are useful in the analysis of G×E interaction, especially for these specific regions, since climate conditions can range drastically from year to year[7]. The complexity of the quality traits is reflected by different responses of genotypes to varying environmental conditions during development. Many breeders have been attempting to understand the importance of G×E interactions by collecting and analyzing phenotypic data from long-term breeding programs[8]. Multi-environmental trials are conducted to determine the sites representing the target environment and to identify the genotypes best suited for specific environmental conditions as well as to find the superior lines and genotypes that can be recommended to breeders[9]. Data collected from such trials can be used for precise estimation of genotype value and yield stability. Besides yield and yield stability increasing seed oil content and further improvement of oil and meal qualities have become one of the most important breeding criteria[10]. Our results are consistent with a significant environmental contribution to the variation in oil content[11]. The environment, genotype and genotype×environment effects were significant at a 1% probability level and genotypes had different performances in different environments[12]. Significant effects of both, genotype (G) and environment (E) as well as the G×E interaction regarding the analyzed seed traits, were obtained in *Brassica napus*[13].

The main efforts by the researchers were aimed to measure this G×E interaction, which helped to recognize well this interaction. It indicates that genotypes react in different ways if environmental conditions change and is of significance for breeders, official test stations and growers. For a cultivar to be a commercially successful one, it must perform well across a range of target environments where the cultivar has to be commercially grown[14]. Since the genotype×environment interaction has a masking effect on the phenotype, some breeders have adapted to estimate the magnitude of this interaction so that, a precise estimate of stability could be obtained. To minimize this interaction, stratification of environments has also been used effectively.

The breeders aim to develop cultivars that are stable across a range of environments. Environments may be locations or years or a combination of both. To measure the environment as the deviation of the mean of all the varieties at locations from the overall mean and recommend growing a variety in the number of environments representing a full spectrum of the possible environmental condition is analyzed using a suitable method[15]. Partitioning of mean squares due to [environment+(genotype×environment)] interaction into three components namely, environments (linear), genotype×environment (linear) and deviation from regression (pooled deviation over all the genotypes). An ideal genotype is defined as one possessing high mean performance, with a regression coefficient around unity ($b_i = 1$) and deviation from regression (S^2d_i) close to zero. Linear regression is regarded as the measure of the linear response of a particular genotype to the changing environment. If the regression coefficient (b_i) is greater than unity, the genotype is said to be highly sensitive to environmental fluctuations but adapted to high yielding environments. If the regression coefficient (b_i) is equal to unity, it indicates the average sensitivity to environmental fluctuations and adaptability to all environments. If the regression coefficient (b_i) is less than unity, it indicates less sensitivity to environmental changes and if this is accomplished by a high mean value, then the genotype is said to be better adapted for poor conditions. The non-significant linear (b_i) and non-linear (S^2d_i) estimates the average stability of genotypes across different environments, whereas significant b_i and non-significant S^2d_i values indicate stability in specific environments. However, the significance of the S^2d_i estimate, irrespective of whether the corresponding b_i estimate is significant or non-significant would suggest that the behaviour of the genotype is unpredictable.

Significant mean squares have been reported for most of the traits in *Brassica* genotypes over environments[16]. For genotype×environment interaction, significant mean squares have been reported[17-19]. The variance due to genotype×environment (linear), genotype (G) and environments (E) were found significant for various traits in Brown sarson[20]. The variance due to genotypes' environments (linear) was found significant for various traits[1]. Significant mean squares for pooled deviation (non-linear) regarding various traits have been reported[18]. Significant differences in oil content among genotypes have also been reported[20]. Stability parameters for oil content revealed that the genotypes KBS-33 and KBS-49 were having 25% more oil content as compared to the check varieties and possessed significant variability for all the traits and some of the elite lines could be used as parental stocks for crop improvement programmes.

CONCLUSION

The genotypes possessed highly significant variability for oil content. The mean squares due to environments were also significant for the trait indicating the environments selected were random and were different in agro-climatic conditions. Interaction of genotypes with the environment (G×E) was observed to be significant for the trait, thereby revealing that genotypes performed differently for the trait under study at different locations. The mean squares due to pooled deviation (non-linear) were significant for the quality trait revealing that the non-linear component was important for these traits which contributed to the total G×E interaction. Thus the genotypes differed considerably for stability for the trait under investigation over the environments.

SIGNIFICANCE STATEMENT

Stability parameters for oil content revealed that the genotypes KBS-33 and KBS-49 were having 25% more oil content as compared to the check varieties and possessed significant variability for all the traits and some of the elite lines (KBS-49, KBS-33, KBS-38) could be used as parental stocks for crop improvement programmes.

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