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Genotypic responses for yield and seed oil quality of two *Brassica* species under semi-arid environmental conditions

M. Iqbal *, N. Akhtar, S. Zafar, I. Ali

Department of Botany, Government College University, Faisalabad, Pakistan

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Abstract

Comparative performance of ten genotypes each of two *Brassica* species (*B. napus* L. and *B. juncea* (L.) Czern. & Coss.) was assessed in a field experiment conducted under semi-arid environmental conditions. Genotypes of both *Brassica* species showed great variability for different morphological characteristics like plant height, primary branches per plant, days to 50% flowering and maturity as well as for yield and yield characteristics. *Brassica juncea* produced significantly greater yield and yield parameters than *B. napus* genotypes. Seed oil content was higher in *Brassica napus* while the levels of erucic acid and glucosinolates were lower in *B. napus* than in *B. juncea*. The results suggested that genotypes RBN-03255 and RBN-03035 of *B. napus* with higher oil content could be recommended for cultivation for commercial use. Moreover, the great variability in oil glucosinolates and erucic acid content in genotypes of *B. napus* showed their potential for utilization in breeding programs at intra- and inter-specific level.

Keywords: *Brassica* species; Erucic acid; Genotypic variations; Glucosinolates; Oil content

1. Introduction

A number of useful farm crops that are extensively grown as cash crops, fodder and industrial crops belong to the *Brassica* family. The seed crops of *Brassica* grown for industrial purposes are rapeseed (*Brassica campestris* L. and *B. napus* L.) and mustard (*B. juncea* (L.) Czern. & Coss. and *B. carinata* A. Br.), which are usually grown in the arid and semi-arid regions of the world, particularly in Pakistan.

Rapeseed is a rich source of oil and protein. The seed has an oil content of 40–42%. The seed meal has a protein content of 43.6% and has a complete component of amino acids including lysine, methionine and cystine. However, compared to rapeseed, canola seed contains a reduced content of erucic acid and glucosinolates. Erucic acid is a long-chain monounsaturated fatty acid that has been shown to cause heart triglyceride accumulation in experimental animals, resulting in the production of heart lesions (Beare-Rogers et al., 1972; Engfeldt and Brunius, 1975). Traditional rapeseed oil contains 20–55% erucic acid (Badawy et al., 1994) that is considered unsuitable for human consumption. Canola oil on the other hand, contains less than 2% erucic acid (Dupont et al., 1989), an amount that is considered safe. Low-erucic acid rapeseed oil contains slightly more erucic acid than canola oil (<5% of total fatty acids).

Glucosinolates are responsible for the pungent odour and biting taste. However, glucosinolates themselves are not directly responsible for toxicity, but when they are hydrolysed by plant or bacterial myrosinase, the result is the production of potentially toxic compounds such as isothiocyanates and nitriles. In animals, the major effects of glucosinolate had been observed on thyroid glands (Fenwick and Heaney, 1983), adrenal glands, kidneys, and liver, and in poultry a fishy taint and the discoloration of the eggs (Fenwick et al., 1981). Although glucosinolate breakdown products are responsible for various toxic symptoms including lesions of liver and kidneys and thyroid dysfunction (Duncan and Milne, 1993), the products of their hydrolysis can protect against cancer (Paolini, 1998; Keum et al., 2004).

* Corresponding author. Tel.: +92 41 9201488; fax: +92 41 9200671.
E-mail address: iqbaluaf@yahoo.com (M. Iqbal).

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The advantages of *B. juncea* over *B. napus* include more vigorous seedling growth, quicker ground covering ability, greater tolerance to different stresses and enhanced resistance to the blackleg fungus, *Leptosphaeria maculans* (Woods et al., 1991; Burton et al., 1999). *B. juncea* seed pods shatter less readily and seeds potentially contain a higher percentage of oil and protein. The oil of both species is low in saturated fatty acids. The potential benefits of developing canola quality *B. juncea* are recognised by a number of northern hemisphere countries, particularly Canada, where there are major breeding programs focused on its development.

Different species of *Brassica* possess substantial genetic variation in various traits responsible for higher yields and stress tolerance. Accordingly, utilization of the magnitude of genetic variation available in the gene pool of *Brassica* species could enhance desirable growth and yield characteristics in both species. The present study was, therefore, planned to evaluate the production potential of various genotypes of *B. napus* and *B. juncea* grown under semi-arid conditions. In addition, the results presented could also be utilized in future breeding programs.

2. Materials and methods

Seeds of ten genotypes each of both *B. juncea* Czern. & Coss. (brown mustard) and *Brassica napus* L. (oilseed rape) were obtained from Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan (Table 1). A field experiment was conducted to study the growth performance of different genotypes of *B. juncea* and *B. napus* and also to test their physiological response under Faisalabad environments.

Nitrogen and phosphorous were applied in the form of urea and Triple Super Phosphate (TSP) at the rate of 90 and 60 kg/ha, respectively. All of the phosphorus and 1/3 of the nitrogen was applied as a basal application. Half of the remaining nitrogen was applied at first irrigation and the other half at flowering. Before harvesting, data for various morphological characteristics such as plant height, number of primary branches per plant, number of plants per plot, days to 50% flowering, and days to maturity were recorded.

Seed oil content was estimated as described by Robbertson and Morrison (1979) on NMR. Erucic acid was determined by gas chromatography. Briefly, 200 mg of seeds from each treatment was extracted in 2 mL petroleum ether. One mL of H_2O was added to the methylated supernatant solution (0.5 mL), vortexed and left for 10 min. One microliter of supernatant was injected into the gas chromatograph and the erucic acid content determined according to Freedman et al. (1986).

Table 1
Different genotypes of *Brassica* species used in the present studies

Brassica juncea	*Brassica napus*
RBJ-96024	RBN-03033
RBJ-96026	RBN-03035
RBJ-97001	RBN-03044
RBJ-99026	RBN-03046
RBJ-2K034	RBN-03052
RBJ-02019	RBN-03057
RBJ-03046	RBN-03060
RBJ-03047	RBN-03075
RBJ-03050	RBN-03255
Khanpur Raya	Rainbow

Glucosinolates were determined by the enzymatically released glucose method (Freedman et al., 1986). At maturity, yield and yield components were determined. Data for all attributes were subjected to analysis of variance (ANOVA) using the GLM module of Costat (CoHort Software, Monterey, CA, USA). Duncan's multiple range test was used to separate treatment means in case of a significant *F*-test at $P<0.05$.

3. Results and discussion

3.1. Growth and morphological characteristics

Different *Brassica* genotypes varied greatly in their average plant height. However, all genotypes of *B. juncea* had a greater mean plant height than those of *B. napus*. The variety "Khanpur Raya" was the tallest (227.75 cm) of all plants (Table 2). The shortest plants were of the genotypes RBN-03046 and RBN-03035 with an average plant height of 169.5 and 170.75 cm, respectively. The other genotypes of *B. napus were* statistically on par as the differences among them were non-significant.

The average number of primary branches per plant of all entries from *B. juncea* group was higher than the number of primary branches per plant of *B. napus* (Table 2). Amongst all genotypes, RBJ-97001, RBJ-03047 and Khanpur Raya produced the highest number of primary branches per plant. The smallest number of primary branches per plant was found on *B. napus* RBN-03035 and *B. juncea* RBJ-99026. The number of primary branches per plant of the remaining genotypes did not differ significantly from each other.

Data for number of plants per plot showed that the differences in mean number of plants per plot were non-significant. The number of days to 50% flowering varied in different genotypes (Table 2). On average the number of days to 50% flowering was more in *B. napus* than in *B. juncea*. The time to 50% flowering was longest in genotypes RBN-03060, RBN-03255 and RBN-03057 of *B. napus* (more than 81 days) and shortest in the variety Khanpur Raya and genotype RBJ-97001 of *B. juncea* (52 days).

The analysis of variance showed highly significant differences for days to maturity between the genotypes tested. The genotypes of *B. juncea* matured faster than those of *B. napus* (Table 2). The time to mature was shortest in "Khanpur Raya", followed by RBJ-99026 and RBJ-02019.

The differences in plant height observed between the different *Brassica* species in the present studies support the findings of other researchers (Ashraf and Sarwar, 2002; Singh and Chakraborty, 2003). These results indicate that breeders have a good range of genotypes from which to select the desired plant height suited to specific agro-climatic regions and environments. The variations in plant height and number of branches per plant exist between species to species, sub-species and varieties of the same species due to variations in genetic makeup. However, environmental conditions (soil texture, soil fertility, soil pH, soil moisture contents, light intensity, and soil