Effect of seed rates on yield and oil components of canola genotypes

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Citation

Abstract
An experiment entitled “Effect of seed rates on yield and oil components of canola genotypes” was conducted at Bacha Khan Agricultural Research Farm (BARF), Bacha Khan University Charsadda during winter-2015. The experiment consisted of two factors; seed rates (4, 6, 8 and 10 kg ha⁻¹) and canola genotypes (Durr-e-NIFA and Zahoor Swati) in randomized complete block design with three replications. A plot size of 3mx2m having 5 rows each 40cm apart was used. Nitrogen (N) and phosphorus (P) were applied at the rate of 60 and 75 kg ha⁻¹ as recommended doses. Full dose of P was applied at sowing while N was applied in two splits (half at sowing time and half with first irrigation). All the plots received the same Agronomic practices. Results of the data revealed that maximum days to emergence (8) were taken by seed rate of 8 and 10 kg ha⁻¹. Number of siliques m⁻²(34825) and oil yield (989 kg ha⁻¹) were maximum with 10 kg ha⁻¹ seed rate. Higher number of siliques plant⁻¹ (397) was produced by using seed rate of 8 kg ha⁻¹. Maximum number of grains siliques plant⁻¹ (22) was produced by seed rate of 6 and 8 kg ha⁻¹. Higher oil content (47%) was recorded for seed rate of 6 kg ha⁻¹. The maximum harvest index (77%) was shown by plots treated with seed rate of 4 kg ha⁻¹. The genotype Durr-e-NIFA resulted in maximum days to emergence (8), number of silique plant⁻¹ (388), number of grains silique⁻¹ (22), harvest index (62 %) and oil yield (871 kg ha⁻¹). Maximum siliques m⁻² (30133) and oil content (47 %) were recorded in genotype Zahoor Swati Swati. The seed rate of 6 kg ha⁻¹ in combination with Durr-e-NIFA gave maximum (413) siliques plant⁻¹ and grain oil content of 48.2% in the interaction.

Keywords: Canola genotypes; Oil components; Seed rates; Yield components

Introduction
Canola (Brassica napus L.), a member of the Brassicaceae family, has the lowest levels of saturated fatty acids in its oil compared to other vegetable oils [1]. It is the 3rd largest source of vegetable oil in the world after palm and soybean and is the basic source of vegetable oil in Pakistan. It is an annual Rabi/winter crop and the normal time of seeding of most of its cultivars in Pakistan is from mid-October to mid-November. Maintaining optimum plant density in
canolais very difficult in the cold regions where low temperature in autumn decreases germination percentage [2]. The production of canola was enhanced by six folds from 1975 to 2007 all over the world [3]. Its production was 58.4 million tons in 2010-2011 growing season worldwide [4]. Canola occupied a total area of 27 million ha worldwide in 2005 [5]. The yield, adaptation, blackleg resistance and quality of canola were improved from 1970 to 2000 [6]. The oil and protein content of canola is 40-45 and 36-40 percent respectively. Canola has replaced soybean meal and oil as an acceptable alternative [7, 8]. Saturated fats are found in a small amount (only 6%) in canola oil [9]. In Pakistan, canola was grown on 213.9 thousand hectares area resulting in the production of 215.8 thousand tons having an average yield of 1009 kg ha⁻¹ whereas in Khyber Pakhtunkhwa, it occupied 14.3 thousand hectares area with production of 6.7 thousand tons with the average yield of 469 kg ha⁻¹ [10]. The yield in Pakistan is still very low as compared to other developing countries of the world. The consequences in low canola production are unavailability of high yielding cultivars and poor crop management practices. Seed rate is one of the basic factors which affect almost all attributes of a crop because it is important for maintaining optimum plant population. Without optimum plant population in all crops especially in canola, it is almost impossible to harvest an economic produce from the crop. By increasing plant density, an increase was noticed in grain yield of canola [11]. According to [12], plant population of 110 plants m⁻² decreased the number of branches and siliques plant⁻¹. Canola gave seed yield for a wide range of plant populations [13]. Higher plant population should be used in order to suppress weeds in early growth stages of canola [14]. Increased variability in the stand was found to reduce seed yield in winter canola [15]. Increase in the seed rate beyond 8 kg ha⁻¹ declined number of pods plant⁻¹ and number of seeds pod⁻¹ [16]. Seed rates significantly affected days to maturity, siliques m⁻², grains silique⁻¹, 1000-grain weight, grain yield and oil percentage [4]. Increasing seed rate up to 8 kg ha⁻¹ resulted in maximum seed yield [17].

For a researcher, it is important to grow different genotypes of a crop in order to investigate better results depending on the agro-climatic conditions of the locality. A genotype may give a very good production in a specific region but it is not necessary that it will give the same result in terms of yield in other regions too. So, selecting a suitable genotype for an agricultural climate is the pre-requisite for getting better production. Yield varies considerably among different genotypes [18]. To increase crop yield, an essential factor is genotypes having high production potential and vigor [19]. Genotypes of canola differ in terms of grain yield, oil yield, number of pods plant⁻¹ and number of seeds pod⁻¹ [20]. Because of different genetic potential, some genotypes are tall while others are dwarf [21]. To get a better production; the seed quality, growth and development potential and resistance to diseases are of great importance to be kept in mind because none of genotypes contains all the desired characteristics [22].

Therefore, the present study was planned to investigate the optimum seed rate and genotype for increased yield and oil components of canola.

**Materials and methods**

**Experimental site**

A field experiment entitled “Effect of seed rates on yield and oil components of canola genotypes” was carried out at Bacha Khan Agricultural Research Farm (BARF), Bacha Khan University, Charsadda during winter-2015.
**Design and treatments**

The experiment consisted of two factors i.e. seed rate at 4 levels at the rate of 4, 6, 8 and 10 kg ha\(^{-1}\) and two genotypes of canola (Durr-e-NIFA and Zahoor Swati). The treatments were arranged in randomized complete block design with three replications.

**Crop management**

Field was thoroughly ploughed two times with cultivator followed by planking and a fine seed bed was prepared through rotavator. Layout was established and plot size of 3mx2m having 5 rows 3m long and 40cm apart from each other was maintained. Sowing was done on 20\(^{th}\) Oct. through manual method using hand hoe upon proper moisture condition of soil. Nitrogen (N) and phosphorus (P) were applied at the rate of 60 and 75 kg ha\(^{-1}\) from urea and single super phosphate respectively. All the P and half of the N were applied at the time of seed bed preparation, while the remaining half of N was applied at the time of first irrigation after twenty days of emergence. Weeding was practiced uniformly in all the experimental units and weeding was done after 45 days of emergence with the help of khudal (hand tool). Irrigation was applied according to crop water requirement keeping in view the climatic conditions like rainfall etc.

**Observations**

Data were recorded on days to emergence, number of siliques plant\(^{-1}\), number of siliques m\(^{-2}\), number of grains silique\(^{-1}\), harvest index, oil content and oil yield. Data for days to emergence were recorded from the date of sowing till 80% seedlings emerged in each plot. Number of siliques plant\(^{-1}\) was recorded by counting number of siliques in 8 plants in three central rows and were averaged. Number of siliques m\(^{-2}\) were recorded by counting number of siliques in three central rows at different locations, each row of one meter length and were converted into number of siliques m\(^{-2}\) by using equation 1. For number of grains silique\(^{-1}\), grains were counted in 8 randomly selected siliques of different size and were averaged; the average was taken as number of grains silique\(^{-1}\). Harvest index was calculated by using equation 2—dividing grain yield by biological yield and was multiplied by 100. To record oil content, sample of each bulk of grains was analyzed by using the “Near Infra-red Reflectance Spectroscopy (NIRS)” system at Oilseed Quality Lab, Crop Breeding Division, NIFA Peshawar [24]. The oil yield was recorded through equation 3.

\[
\text{Number of silique } m^{-2} = \frac{\text{Total No. of siliques counted}}{R - R \text{ distance (m)} \times \text{row length (m)} \times \text{No. of rows}} \\
\text{H.I. (%) } = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100 \\
\text{Oil yield } = \frac{\text{Grain yield} \times \text{Oil content}}{100}
\]

**Statistical analysis**

Data were statistically analyzed by ANOVA technique appropriate for RCB design. Least significant difference test was carried out at 5% level of probability upon significant F test [23].

**Results**

**Days to emergence**

Days to emergence of canola genotypes as affected by seed rates are presents in (Table 1). Results revealed that seed rates, genotypes as well as S x G did not affect days
to emergence significantly. However on the average, seed rates of 8 and 10 kg ha\(^{-1}\) took 8 days to emergence while seed rates of 4 and 6 kg ha\(^{-1}\) took 7 days to emergence. In case of genotypes, the genotype Zahoor Swati and Durr-e-NIFA took 8 and 7 days to emergence respectively.

**No. of siliques plant\(^{-1}\)**

The effect of seed rates and genotypes on number of siliques plant\(^{-1}\) is shown in (Table 1). Statistical analysis showed that seed rates, genotypes as well as their interaction affected number of siliques plant\(^{-1}\) significantly.

Among seed rates, 8 kg ha\(^{-1}\) produced maximum (397) siliques plant\(^{-1}\) which was statistically at par with 6 kg ha\(^{-1}\) (395) while minimum siliques plant\(^{-1}\) (350) were recorded with seed rate of 4 kg ha\(^{-1}\) which were statistically similar to 10 kg ha\(^{-1}\) (361). On the basis of genotypes, Durr-e-NIFA produced more siliques plant\(^{-1}\) (388) as compared to Zahoor Swati (364). In case of interaction, seed rate of 6 kg ha\(^{-1}\) in combination with Durr-e-NIFA gave maximum (413) siliques plant\(^{-1}\) (Figure 1).

**Table 1. Days to emergence, number of siliques plant\(^{-1}\) and number of siliques m\(^{-2}\) of canola as affected by seed rates and genotypes**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Days to emergence</th>
<th>Number of siliques plant(^{-1})</th>
<th>Number of siliques m(^{-2})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seed rate (S) (kg ha(^{-1}))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>350b</td>
<td>20848c</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>395a</td>
<td>27314b</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>397a</td>
<td>33425a</td>
</tr>
<tr>
<td>10</td>
<td>8</td>
<td>361b</td>
<td>34825a</td>
</tr>
<tr>
<td><strong>LSD value</strong></td>
<td><strong>Ns</strong></td>
<td><strong>28.756</strong></td>
<td><strong>1643.227</strong></td>
</tr>
<tr>
<td><strong>Canola genotypes (G)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durr-e-NIFA</td>
<td>7</td>
<td>388a</td>
<td>28074</td>
</tr>
<tr>
<td>Zahoor Swati</td>
<td>8</td>
<td>364b</td>
<td>30133</td>
</tr>
<tr>
<td><strong>LSD value</strong></td>
<td><strong>Ns</strong></td>
<td><strong>20.334</strong></td>
<td><strong>Ns</strong></td>
</tr>
<tr>
<td><strong>LSD value for interaction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S x G</td>
<td><strong>Ns</strong></td>
<td><strong>40.667</strong></td>
<td><strong>Ns</strong></td>
</tr>
</tbody>
</table>

Means in the same category followed by different letters are significantly different at P ≥0.05 levels. * = significant. Ns = non-significant.

**Figure 1. Number of siliques plant\(^{-1}\) of canola as affected by seed rates and genotypes**
No. of siliques m\(^{-2}\)
Data for affect of seed rates and genotypes on number of siliques m\(^{-2}\) are given in (Table 1). Seed rates affected number of siliques m\(^{-2}\) significantly however genotypes and S x G were found non-significant. Seed rate of 10 kg ha\(^{-1}\) produced highest number of siliques m\(^{-2}\) (34825) which was statistically same to that of 8 kg ha\(^{-1}\) while lowest number of siliques (20848) was noted for 4 kg ha\(^{-1}\).

No. of grains silique\(^{-1}\)
Effect of seed rates and genotypes on number of grains silique\(^{-1}\) of canola is presented in (Table 2). By analyzing the data statistically, it was shown that number of grains silique\(^{-1}\) was significantly affected by seed rates and genotypes, S x G was found non-significant. Maximum grains silique\(^{-1}\) (22) were produced by 8 and 6 kg ha\(^{-1}\) which were statistically similar to that of 10 kg ha\(^{-1}\) (21) while least number of grains silique\(^{-1}\) (18) were produced by 4 kg ha\(^{-1}\). In case of genotypes, Durr-e-NIFA produced more grains silique\(^{-1}\) (22) compared to Zahoor Swati (19).

Harvest index (%)
Table 2 shows data regarding harvest index of canola as affected by seed rates and genotypes. Statistical analysis of the data revealed that seed rates affected harvest index significantly while genotypes and S x G did not affect harvest index at significant level. Maximum harvest index (77%) was shown by 4 kg seed rate ha\(^{-1}\) whereas minimum harvest index (47%) was shown by 8 kg ha\(^{-1}\).

Grain oil content (%)
Grain oil content of canola was significantly affected by seed rates, genotypes as well as S x G (Table 2). Among seed rates, 8 kg ha\(^{-1}\) produced highest grain oil content (47.3%) while 8 kg ha\(^{-1}\) resulted in least grain oil content (45.2%) which was statistically at par with that of 6 kg ha\(^{-1}\) (45.3%) and 10 kg ha\(^{-1}\) (45.6%). With respect to genotypes, Zahoor Swati produced maximum grain oil content (46.6%) while Durr-e-NIFA produced minimum grain oil content (45.1%). In case of interaction between seed rates and genotypes, genotype Durr-e-NIFA in combination with seed rate of 6 kg ha\(^{-1}\) resulted in maximum grain oil content (48.2%) (Figure 2).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Number of grains silique(^{-1})</th>
<th>Harvest index (%)</th>
<th>Grain oil content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed rate (S) (kg ha(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>18b</td>
<td>77a</td>
<td>45b</td>
</tr>
<tr>
<td>6</td>
<td>22a</td>
<td>66b</td>
<td>47a</td>
</tr>
<tr>
<td>8</td>
<td>22a</td>
<td>47d</td>
<td>45b</td>
</tr>
<tr>
<td>10</td>
<td>21a</td>
<td>55c</td>
<td>46a</td>
</tr>
<tr>
<td>LSD value</td>
<td>2.486</td>
<td>5.109</td>
<td>1.443</td>
</tr>
<tr>
<td>Canola genotypes (G)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Durr-e-NIFA</td>
<td>22a</td>
<td>62</td>
<td>45b</td>
</tr>
<tr>
<td>Zahoor Swati</td>
<td>19b</td>
<td>61</td>
<td>47a</td>
</tr>
<tr>
<td>LSD value</td>
<td>1.758</td>
<td>Ns</td>
<td>1.020</td>
</tr>
<tr>
<td>LSD value for interaction</td>
<td></td>
<td></td>
<td>2.040</td>
</tr>
</tbody>
</table>

Means in the same category followed by different letters are significantly different at P ≥0.05 levels. * = significant. Ns = non-significant
Oil yield (kg ha\(^{-1}\))

Data about oil yield of canola as affected by seed rates and genotypes are presented in (Table 3). Statistical analysis of data revealed that seed rates and genotypes had significant effect on oil yield while S x G remained non-significant for its effect on oil yield. Maximum oil yield (989 kg ha\(^{-1}\)) was recorded for plots treated with 10 kg ha\(^{-1}\) seed rate while minimum oil yield (719 kg ha\(^{-1}\)) was noted for the plots in which seed rate of 4 kg ha\(^{-1}\) was used. With respect to genotypes, Durr-e-NIFA produced maximum oil yield (871 kg ha\(^{-1}\)) while Zahoor Swati gave minimum oil yield (809 kg ha\(^{-1}\)).

Discussion

Seed rates, genotypes and S x G did not affect days to emergence of canola significantly. The reason may be the fact that soil and environmental conditions affect emergence to a large extent. Such conditions can be soil texture, soil structure, soil porosity, moisture content of soil etc. That is why seed rates and genotypes did not affect days to emergence. Another reason can be the fact that during the germination and emergence processes, seeds utilized their own food and thus did not depend on seed rate or genotype for days to emergence. The same results were previously reported by [25]. Seed rates, genotypes and S x G affected number of siliques plant\(^{-1}\) in canola crop significantly. Maximum siliques plant\(^{-1}\) were recorded from the plots treated with 8 kg ha\(^{-1}\) seed rate while seed rate of 4 kg ha\(^{-1}\) produced minimum number of siliques plant\(^{-1}\). The probable reason for higher siliques plant\(^{-1}\) due to medium level of seed rate might be that at higher seed rate the plant density was higher, so as a result of this the number of branches were reduced which resulted in lower siliques plant\(^{-1}\). Moreover, the inter plant competition might be higher at higher seed rate which resulted in lower siliques plant\(^{-1}\). Our results are supported by [13]. On the bases of genotypes, Zahoor Swati produced more number of siliques plant\(^{-1}\) as compared to Durr-e-NIFA which might be due to the differences in genetic makeup of the tested genotypes. The same results were
reported by [26] who stated that cultivars showed significant difference for number of siliques plant$^{-1}$. In case of interaction, Durr-e-NIFA genotype resulted in higher number of siliques plant$^{-1}$ by increasing seed rate up to 6 kg ha$^{-1}$.

Table 3. Oil yield of canola as affected by seed rates and genotypes

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Oil yield (kg ha$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seed rate (S) (kg ha$^{-1}$)</strong></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>719d</td>
</tr>
<tr>
<td>6</td>
<td>817c</td>
</tr>
<tr>
<td>8</td>
<td>836b</td>
</tr>
<tr>
<td>10</td>
<td>989a</td>
</tr>
<tr>
<td>LSD value</td>
<td><strong>68.260</strong></td>
</tr>
<tr>
<td><strong>Canola genotypes (G)</strong></td>
<td></td>
</tr>
<tr>
<td>Durr-e-NIFA</td>
<td>871a</td>
</tr>
<tr>
<td>Zahoor Swati</td>
<td>809b</td>
</tr>
<tr>
<td>LSD value</td>
<td><strong>48.267</strong></td>
</tr>
<tr>
<td><strong>LSD value for interaction</strong></td>
<td>Ns</td>
</tr>
</tbody>
</table>

Means in the same category followed by different letters are significantly different at P ≥0.05 levels. * = significant. Ns = non-significant.

Seed rates significantly affected number of siliques m$^{-2}$ in canola crop while genotypes and S x G were found non-significant. Maximum siliques m$^{-2}$ were produced by seed rate of 10 kg ha$^{-1}$ whereas least siliques m$^{-2}$ were noted for seed rate of 4 kg ha$^{-1}$. It might be due to the higher plant density of higher seed rate which resulted to emerge more seedlings, thus resulting in more number of siliques m$^{-2}$. Our results are in line with [27] who stated that there was significant difference among cultivars of canola for number of seeds pod$^{-1}$.

Seed rates significantly affected harvest index of canola while genotypes and S x G were non-significant for their effect on harvest index. Maximum harvest index was recorded for seed rate of 4 kg ha$^{-1}$. Minimum harvest index was shown by seed rate of 8 kg ha$^{-1}$. The same results were previously reported by [27] who concluded that harvest index decreased with increasing seed rate.

Number of grains silique$^{-1}$ was significantly affected by seed rates and genotypes however S x G was found to be non-significant in this regard. Maximum number of grains silique$^{-1}$ was given by seed rate of 8 kg ha$^{-1}$ while minimum number of grains silique$^{-1}$ was recorded for the seed rate of 4 kg ha$^{-1}$. The reason for this might be the fact that there was moderate competition among the plants of optimum seeding rate and thus plants received relatively better nutrition which resulted to produce more grains silique$^{-1}$. The same results were previously concluded by [16]. In case of genotypes, more grains silique$^{-1}$ were produced by Durr-e-NIFA as compared to Zahoor Swati. Our results are in line with [26] who stated that there was significant difference among cultivars of canola for number of seeds pod$^{-1}$.

Seed rates significantly affected harvest index of canola while genotypes and S x G were non-significant for their effect on harvest index. Maximum harvest index was recorded for seed rate of 4 kg ha$^{-1}$. Minimum harvest index was shown by seed rate of 8 kg ha$^{-1}$. The same results were previously reported by [27] who concluded that harvest index decreased with increasing seed rate.

Seed rates, genotypes as well as their interaction had significant effect on the grain oil content of canola. 6 kg seed ha$^{-1}$ resulted in maximum grain oil content while minimum grain oil content was produced by seed rate of 4 kg ha$^{-1}$. Our results are in agreement with [4] that grain oil content of brassica significantly varied with varying seed rates. Based on genotypes, maximum grain oil content was recorded for genotype Zahoor Swati while minimum grain oil content was noted in genotype Durr-e-NIFA. The difference in
the grain oil content of canola genotypes might be due to the genetic variations between them.

The same results were previously reported by [1] who stated that the effect of cultivar was significant for grain oil content of canola. Among the interactions between seed rates and genotypes, higher grain oil content was recorded for the genotype Durr-e-NIFA by enhancing seed rate till 6 kg ha\(^{-1}\).

Significant difference was found for the effect of seed rates and genotypes on oil yield while S x G was non-significant. Maximum oil yield was produced by plots treated with 10 kg ha\(^{-1}\) seed rate while minimum oil yield was noted for the plots in which 4 kg ha\(^{-1}\) seed rate was used. The same results were earlier reported by [17] that different seed rates resulted in different oil yields. With respect to genotypes, Durr-e-NIFA produced maximum oil yield while Zahoor Swati gave minimum oil yield. The reason might be the different genetic makeup of the genotypes. Our results are in line with [20] who stated that oil yield of canola varies with different varieties.

**Conclusions and recommendations**

From the results of the studied parameters, it was concluded that seed rate of 8 kg ha\(^{-1}\) performed the best in terms of number of siliques plant\(^{-1}\) and number of grains silique\(^{-1}\). Highest grain oil content was produced by seed rate of 6 kg ha\(^{-1}\). Oil yield was higher at seed rate of 10 kg ha\(^{-1}\). The genotype Durr-e-NIFA performed better in terms of number of siliques plant\(^{-1}\), number of grains silique\(^{-1}\), harvest index and oil yield. Number of siliques m\(^{-2}\) and oil content were higher in genotype Zahoor Swati. Based on the above results and conclusions, it is recommended that genotype Zahoor Swati should be grown at the seed rate of 6 kg ha\(^{-1}\) to get the highest oil content from canola crop. Moreover, Durr-e-NIFA is recommended to be sown at the seed rate of 10 kg ha\(^{-1}\) for maximum oil yield.

**Authors’ contributions**

Conceived and designed the experiments: B Khan & M Jawad, Performed the experiments: M Jawad, HA Kakar, SN Khan & S Fahad, Analyzed the data: M Jawad, M Islam & Anjum, Contributed materials/ analysis/ tools: M Ahmad, B Khan, M Yar & M Ilyas, Wrote the paper: M Jawad & M Islam.

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