Development high seed yield spring type canola germplasm by utilizing winter type rapeseed lines

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Abstract

Canola is a strategic crop of great importance to North Dakota, is the largest producer of canola in the USA. Increasing seed yield in canola is an important breeding objective for the growers and seed industry. The yield potentiality of winter type rapeseed is over two-fold compared to spring type canola. Because of severe winter hardiness, winter type canola is not possible to grow in North Dakota. Therefore, a breeding program has been taken to develop high seed yield spring canola utilizing winter type rapeseed. Crosses were made between winter and spring type canola. The F_1, F_2 and backcross progenies were grown in the greenhouse of North Dakota State University. The vernalization requirement to flower was observed a recessive trait. The winter parent showed a vigorous root system. The F_2 and backcross population segregated with various root length and root mass. A positive correlation was observed between root length vs. number of pods/plant, and root length vs. seed yield.

Introduction

Rapeseed/canola (*Brassica napus*) is the major oilseed crop grown in major producing countries including China, Canada, France, Germany, India, Poland, the UK, Australia and USA. These countries produce about 98% of total world rapeseed production. On the basis of growing season, rapeseed (*B. napus*) is classified into two groups, such as annual type and biennial type. The annual type is also known as spring type and biennial type is known as winter type. The biennial type of rapeseed is planted in the fall, pass through the winter for vernalization to induce flower in the following spring, and harvest in summer (two years required for the crop cycle). Whereas, the annual type planted in the spring, flower in summer, and harvested at the end summer (require one growing season). In Western Europe, rapeseed is grown as winter crop with highest seed yield of about 4 ton/ha (FAOSTAT, 2009). Canada produces spring type rapeseed with moderate seed yield of 1.9 ton/ha (FAOSTAT, 2009). USA grows both winter and spring type rapeseed, where North Dakota grows spring types canola with about 91% of US production and the average yield is 2.0 ton/ha (FAOSTAT, 2009). Canola got importance in North Dakota as a rotational crop following wheat, and the acreage has expanded from 1.0 million acre of 2009 to 1.4 million acres of 2010.

Canola has a narrow genetic base within the spring and winter types but has greater genetic diversity between the two types to represent distinct gene pools (Quijada et al., 2006; Diers and Osborn 1994). The reason for the low genetic diversity could be the short history of rapeseed cultivation in comparison to its two parental species *B. rapa* and *B. oleracea* (Becker et al. 1995); or it might be a case as breeders have been developing spring type and winter type cultivars separately to keep canola quality in the respective growing zone (Diers and Osborn 1994). Because of severe winter hardiness, spring type canola is a strategic crop of great importance to North Dakota. Increasing seed yield in canola is an important breeding objective because of the market value of the seed.

For canola growers, the main value of canola production is high seed yield per acre. Seed yield is a quantitative character which could be improved by the introgression of favorable genes into cultivated germplasm. A strong positive correlation has been identified between seed yield/ha and oil content in seed (Marjanović-Jeromela et al. 2007). This indicates that increasing seed yield will also contribute to increase oil content in seed. Introgression of favorable characters from winter types into spring types for increased seed yield have been identified by Butruille et al. (1999) and Quijada et al. (2004). A high heterosis for seed yield between European winter and Asian spring type rapeseed cultivars has been reported by Lefort-Buson et al. (1987). Udall et al. (2006) observed increase in seed yield of spring rapeseed after crossing with semi-winter germplasm. Qian et al. (2007) reported that Chinese semi-winter rapeseed germplasm could significantly increase the seed yield in spring rapeseed breeding programs in Canada and Europe. In this research a breeding strategy has been taken to improve spring canola by utilizing winter canola, and to study the correlation of seed yield with other agronomic characteristics.

Materials and Methods

The spring type canola (*Brassica napus*) cultivar "Regent" was collected from USDA-ARS National Plant Germplasm System, and the winter type *B. napus* cv ARC-97018 was collected from the University of Arkansas. Both the parents were self-pollinated for several generations to develop pure breeding lines. The pure breeding line ARC-97018 was crossed with pure breeding cultivar Regent, and the F_1, F_2 and BC_1 were grown in the greenhouse (GH). The winter parent ARC-97018 was vernalized to get flower. The spring parent, F_1, F_2 and BC_1 populations were grown in the GH of North Dakota State University at 72±8°F (day and night). The plants in the GH were provided with a 16-h photoperiod. The seedling were grown 4 weeks in GH conditions and then transferred into vernalization chamber with a temperature 40±4°F. The plants were vernalized for 5 weeks, then transferred to a cold room 55±5°F for 3 days, and finally transferred to the original GH conditions. Data on day to flower, plant height, number of branches/plant, number of pods/plant, pod length, root length, dry stem weight, dry root weight, and seed yield/plant was taken to study the correlation of coefficient among the characters using SAS 9.1 software (SAS Institute Inc., Cary, NC, USA).

Results and discussions

The parents (ARC-97018 and Regents) and the F_1s were grown in the GH. Half of the parents and F_1s were continuously grown in the GH and the rest of the half plants were vernalized. Among the plants grown in the GH, the annual parent Regent and the F_1 hybrid flowered in the unvernalized condition, whereas the winter type parent ARC-97018 did not flower in the unvernalized condition. All the plants in the backcross to the spring parent flowered in the GH. These are indicating that the vernalization requirement to flower is a recessive trait. However, the winter type parent plants flowered after vernalization, but did not flowered in the unvernalization condition. Ferreira et al. (1995) reported similar dominant nature of flowering time of spring type over winter type of *B. napus*. Dominant nature of annual over biennial type for flowering in *B. oleracea* has been reported by Kennard et al. (1994). The F_2 and the BC_1 were not vernalized and grown directly in the GH condition. The flowering started from 60 days after planting and continued up to 150 days after planting. The F_2 plants were classified into two groups, such as plants as having flowered (138 plants) or not flowered (6 plants). The F_2 fit a 15:1 (χ^2 = 1.067, P = 0.2-0.3) phenotypic segregation ratio for flowered plants: not flowered plants. This result indicates that two gene loci are responsible for the vernalization requirement to flower of *B. napus.* Thurling and Das (1979) predicted that the *B. napus* cv Bronowski and *B. napus* cv Isuzu may have two different vernalization requirement genes control the flowering time. In *Arabidopsis thaliana*, many loci with late flowering have been identified and some of them are associated with vernalization to flowering trait (Koornneef et al. 1991). Osborn et al. (1997) identified major QTLs for flowering time in *B. napus* which were corresponded to Arabidopsis flowering time genes.

A correlation coefficient was studied among plant height, branches/plant, number of pods/plant, pod length, root length, dry stem weight, dry root weight, and seed yield/plant. Significant positive correlations were found between branches vs. number of pod (0.58***), branches vs. dry stem weight (0.38*), branches vs. seed yield (0.49**), number of pods vs. root length (0.41*), number of pods vs. dry stem weight (0.43*), root length vs. dry root weight (0.46*), root length vs. seed yield (0.37*), dry stem weight vs. seed yield (0.54**). Numerous researchers have been studied on correlation coefficient of seed yield with other yield contributing characters such as number of branches, pod number, pod length. However, this study has given additional information on the contribution of root length and dry root weight to seed yield, where both (root length and dry root weight) showed a positive contribution to seed yield. This may explain as longer root utilize more nutrient from deep soil resulted higher seed yield.

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