Reprinted from: Perspectives on new crops and new uses. 1999.
J. Janick (ed.), ASHS Press, Alexandria, VA.

Evaluation of Salinity Tolerance of Canola Germination

Naveen Puppala, James L. Fowler, Linnette Poindexter, and Harbans L. Bhardwaj

Canola (*Brassica napus* L., *B. rapa* L., Brassicaceae) is a genetically altered form of rapeseed with low erucic acid, a 22-carbon chain fatty acid that is used in a variety of polymer and lubricant products. Interest in canola is increasing steadily among health-conscious consumers due to its lowest content of saturated fatty acids (<70 g/kg) among major oil seeds. Domestic production of canola would reduce the import costs, enhance the productivity of American farms, and diversify agriculture (Starner et al. 1995). Canola oil is now the third largest source of edible oil following soybean and palm oil (Nowlin 1991). This increased demand, and the need for crop diversification, will undoubtedly promote increased acreage of canola in the western US, where some soils are prone to become saline (Francois 1994). Sims et al. (1993) reported that canola yields in Montana increased greatly with increased availability of water under normal conditions with lowered mean oil content. The average yield of 2.2 to 2.7 t/ha with oil content of 32% to 49% has been reported in Virginia during 1992 to 1995 (Virginia Agricultural Statistics 1995).

The traditional approach to the cropping of arid lands has been to use conventional cultivars and modify the soil and water to meet the needs of the crop, or to make genetic selections from established cultivars for improved performance under arid conditions. Saline soils and saline irrigation waters present potential hazards to canola production. Germination is one of the most critical periods for a crop subjected to salinity. Germination failures on saline soils are often the results of high salt concentrations in the seed planting zone because of upward movement of soil solution and subsequent evaporation at the soil surface (Bernstein 1974). These salts interfere with seed germination and crop establishment (Fowler 1991).

In an effort to develop the low erucic acid cultivars, the plant breeders are at the same time attempting to look for seedlings, which are tolerant to salinity. The two species of canola *B. napus* and *B. campestris* are classified as tolerant to salinity as per Maas and Hoffman (1977) salt tolerance classification table. Maas (1990) reported that even though both the species exhibit high salinity thresholds, the rate of yield decline above the thresholds was much greater than most other crops in the tolerant category. Shafii et al. (1992) reported that winter canola cultivars grown Pacific northwest had significantly higher oil content than the same ones grown in the Southeastern US.

The tolerance of canola to salinity during germination however has not been reported. The objective of this study was to evaluate the germination response of canola to a wide range of cultivars, salinity levels, temperatures, and to determine their interactions.

METHODOLOGY

Evaluation for salinity tolerance during germination was accomplished by placing 50-seed samples in 90 by 15 mm plastic petri dishes containing one blotter paper to which 5 mL of distilled water or various solutions of NaCl and $CaCl_2$ (2:1 molar ratio of NaCl and $CaCl_2$) were added. Germination responses to concentrations of 0, 5.4, 10.1, 16.2, 21.6, and 26.4 dS/m of the combined salts were determined. Electrical conductivities and osmotic potentials were measured with a Model PM-70CB conductivity bridge (The Barnstead Co., Boston, MA) and a Model 5130C vapor pressure osmometer (Wescor, Inc., Logon, UT), respectively. The covered petri dishes were arranged in an incubator in a randomized complete block experimental design with one block per shelf over four shelves. Germination response to salinity at six temperatures (10, 15, 20, 25, 30, and 35°C) was evaluated by replicating the temperatures twice in the same incubator over time. Temperatures were maintained within ±1°C of target levels. Germination counts were made at 3, 6, 9, and 12 days after initiation of germination (DAI). One blank petri dish with a blotter paper per shelf was randomized with the treatment dishes. Distilled water (representing the mean loss of water from the blanks) was added to each petri dish on Day 3, 6, and 9 to maintain salt concentrations near the target levels throughout the germination period. Five cultivars (Falcon, Jetton, HNO31-91, ST9194 and W4689E) were tested for salinity, temperature, salinity × temperature, and salinity × temperature × cultivar responses. Analyses of variance and orthogonal contrasts were used to analyze the data (SAS Institute 1995). Data for each counting date were analyzed independently.

EXPERIMENTAL RESULTS

The germination response of canola seed to a wide range of salinity averaged over cultivars and temperatures are presented in Table 1. Germination generally declined linearly with salinity levels. As the salinity level increased from 10.1 to 16.2 dS/m there was almost 40% reduction in seed germination compared to control. Soils that are higher than 16.2 dS/m salinity can reduce the canola yield due to reduction in plant population.

Among the five canola cultivars used in this study, ST9194 showed significantly higher percent germination on all counting dates and was significantly higher than the other cultivars. This probably represents genetic resistance to salinity and might be exploited as a source of salinity resistance for breeding (Table 2).

Germination was severely limited at 5°C with the control germinating only 23% after 12 days after initiation of germination (DAI). The low germination response at 5°C suggests that this temperature be near the minimum germination temperature for high-quality canola seed. The optimum germination temperature for the control occurred in the 15 to 25°C ranges (Table 3). This range is similar for most of the oilseeds crops. Germination of canola at 0 salt stress was close to 100% after 3 days at 25°C. Significant difference at 0.01 levels were seen among cultivars, salinity levels, and different temperatures were seen at each counting dates. The interactions between cultivar × salinity, cultivar × temperature, and cultivar × salinity × temperature were also highly significant at each counting date at 0.01 levels.

Table 1. Canola germination during a 12 days period in response to different salinity levels averaged over cultivar and temperature.

Salinity levels (dS/m)	Germination (%) Days after initiation 3	6	9	12
0	61.0	76.7	84.2	87.2
5.4	53.3	70.6	79.1	82.3
10.1	40.5	62.7	69.6	72.3
16.2	24.5	46.7	51.9	53.8
21.6	8.3	22.6	26.9	27.8
26.4	0.4	0.6	0.8	0.8
LSD (0.05)	3.1	2.6	3.0	3.0

Table 2. Germination of five canola cultivars as a response to salinity and temperature during a 12 d germination period.

Cultivars	Germination (%) Days after initiation 3	6	9	12
Falcon	24.5	40.4	45.5	47.8
Jetton	29.6	46.8	52.4	55.6
HNO31-91	35.9	49.0	52.8	54.2
ST9194	38.0	55.8	63.0	64.6
W4689E	28.8	41.4	46.8	47.8
LSD (0.05)	2.8	2.4	2.8	2.8

Table 3. Cumulative germination percentage of canola as a response to cultivar and salinity during a 12 days germination period.

Temperature (°C)	Germination (%) Days after initiation 3	6	9	12
5	0	1.0	15.4	22.7
10	0.8	40.6	53.0	57.7
15	39.1	62.4	66.4	67.5
20	48.2	67.9	69.6	69.8
25	53.3	61.1	63.4	63.4
30	45.0	56.2	58.6	58.6
35	33.1	37.7	38.3	38.4
LSD (0.05)	19.5	12.0	13.2	13.6

CONCLUSIONS

Based on the above results, the salinity tolerance of canola seed during germination should be classified as moderately tolerant (Maas and Hoffman 1977) over the 10 to 30°C temperature range. This tolerance classification was determined based on the salinity levels resulting in a 50% reduction in final germination at 12 days. Germination was most tolerant between 15 and 25°C, slightly less tolerant at 10 and 30°C and less tolerant at 35°C, but all falling within the moderately tolerant range.

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