Temperature effects on the germination of rapeseed.

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Introduction

The major limitations to rapeseed production in the province of Alberta in Western Canada are the short frost free period and the cool growing environment. The most serious manifestation of this is the occurrence of a killing frost during the seed development stage prior to maturity. Approximately 50% of the Alberta rapeseed acreage is grown in central Alberta and 30% in the north of the province. *Brassica napus* L. cultivars of rapseed offer the advantage over *Brassica campestris* L. cultivars of higher yield and a reduced volunteer problem. However the acreage of *B. napus* grown in the province is restricted by its long maturity requirement. Some advances have been made in reducing this long maturity requirement by selecting for earlier flowering. An alternative approach is to seed the crop earlier in the spring. However cold soil conditions result in emergence problems particularly in *B. campestris* cultivars. The present recommended soil temperature for the seeding of rapeseed is 15 to 20^{o}C with a minimum of 5^{o}C for *B. napus* and a minimum of 7 to 10^{o}C for *B. campestris* (Anon. 1980). Average soil temperatures in Alberta on May 15 at Ellerslie, Lethbridge and Vegreville for the years 1965-81 were 6.6, 11.4 and 7.6^{o}C respectively. The mean temperature on May 5 were 4.9, 9.6 and 5.5^{o}C (Environment Canada). In central and northern Alberta therefore it would be advantageous to have cultivars that would germinate at temperatures below 5^{o}C.

Genetic variation for germination tolerance to low temperatures has been observed in many crop species; *Phaseolous vulgaris* L. (Dickson, 1971), *Zea mays* (Pesev, 1970), *Pisium sativum* L. (Torfason and Nonnecke, 1957), *Glycine max* (L.) Merr. (Littlejohns and Tanner, 1976) and *Gossypium hirsutum* L. (Buxton and Sprenger, 1976). Witcombe and Whittington (1971) found that the germination rate of *B. napus* seeds decreased as the temperature was decreased from 25°to 5°C. The germination of mustard and cabbage seed in a block of ice was reported by Timiriazift (cited by Coffman, 1923) and germination of Brassica hirta Moench. at 0°C if water was present in the liquid state.

This study was initiated to determine if genetic variability was present in Canadian rapeseed cultivars and breeding material for germination percent and germination rate at a range of temperatures. The effectiveness of selecting within genetic lines for slow and fast germinators at extreme temperatures was also tested.

Method

Preliminary tests (Kondra 1980, unpublished) were conducted to determine a suitable germination procedure. Petri dishes of 100 mm diameter and 25 mm deep with 25 ml of 50/60 mesh silica sand and 8-5 ml of distilled water were utilized. Untreated seed was placed on the surface of the sand. The germination cabinet was a modified refrigerator with an electronic temperature controller and forced air circulation. Temperatures were monitored with a strip chart recorder. Temperature fluctuation was ±0.2°C of the set temperature.

a) Germination temperatures were 2, 3, 5, 7, 9, 15, 21 and 25°C. The seed material tested was: B. napus cultivars Altex, Midas, Regent and lines 75G-908 and 74G-1382 from the University of Alberta; B. campestris cultivars Torch, Candle and line S74-4478 from the University of Manitoba. At each temperature there were ten replicate Petri dishes for each genotype with 32 seeds per dish. At the lower temperatures the seeds were monitored twice daily. At 21 and 25°C it was necessary to record germination every two hours. Seed was considered germinated when the radicle emerged through the testa. The percent germination and mean germination time were recorded. Analysis of variance was performed to compare the two species at each temperature using the genotype-replicate combinations as replicates. Subsequently, each species was analysed separately to compare genotypes. The percent germinations were arcsin transformed for the analysis. Tukey's test for differences between means was applied only when analysis of variance was significant.

b) In 1981 screening was begun to investigate the possibility of selecting within genetic lines of B. napus for speed of germination at two extreme temperatures. In 1982 this programme was extended to include lines of B. campestris. In the spring of 1981 seed from the B. napus cultivar Andor and from ten B. napus lines in the University of Alberta breeding programme was screened at both 2 and 25°C. The test was as described above with ten replicate dishes each containing thirty two seeds from each line at each temperature. The fastest 10% and slowest 15% of seeds germinating from each line at each temperature were selected and planted out in the field. Ten plants from each selection were selfed. In the spring of 1982 the test was repeated with seed from each selfed plant being reselected under the relevant temperature condition. Thus the seeds from plants selected as fast germinators at 2° C in 1981 was screened again at 2°C and the fastest four seeds from each plant retained. Under this test each of the ten replicate dishes for a line contained seed from a different selected selfed plant. The germination rate of these seeds was compared with the germination rate of seeds from unselected plants using a paired 't' test.

Results and Discussion

a) Seeds of *B. campestris* cultivars had a significantly lower germination percent than *B. napus* at temperatures below 9°C and at 25°C (Table 1). The percent germination did not demonstrate any temperature trends for *B. napus*, but *B. campestris* germination was severely reduced at 2 and 3°C. Significant differences between genotypes of *B. campestris* occurred at all temperatures except 21 and 25°C. Candle consistently had the lowest percent germination. Significant differences between genotypes of *B. napus* occurred at all temperatures except 2, 9 and 25°C. Regent consistently had the lowest percent germination. However the differences among *B. napus* genotypes were considerably less than for *B. campestris*.

There were significant differences between species at all temperatures for mean germination time (days), (Table 2). *B. napus* was more rapid at 2, 3, and 5°C with *B. campestris* more rapid at the higher temperatures. The rate of germination declined rapidly for both species with declining temperature. Significant differences within *B. campestris* occurred only at 2, 3 and 15°C. Differences were small and no trends were obvious. Significant differences within *B. napus* occurred at all temperatures except 21°C. The differences were small but Regent generally exhibited the lowest rate.

b) In Table 3 the mean germination time in days is given for the seeds selected as fast and slow germinators at each temperature in 1982. The results show a considerable range in time to germination for each line, the variance being much greater at the lower temperature. The days to germination of the fastest seed from each line is also recorded. In all lines except 791520 and 8045849B it was possible to select seeds that would germinate in two days at 2°C. When the time to germination of the seeds from selected plants was compared to the germination rate of seeds from unselected plants however there was no significant difference between the two populations for any of the eleven lines.

It would appear therefore that although preliminary tests identified a considerable range in germination rate both within and between the B. napus lines studied, selecting for extremes of germination rate within lines was unsuccessful. This suggests that the within line variation exhibited by this character was not under genetic control. In order to explain the apparent differences in germination rate observed between lines it will be necessary to make crosses between the lines and then select for extremes of germination rate following a recurrent selection method. It remains to be seen whether selection within lines of B. campestris for extremes of germination rate will be successful. Differences between genotypes of B. campestris in percent germination at low temperatures indicate that there may be potential for selecting for improved germination percent and hence better stand establishment at low temperatures.

References

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Table 1. Percent germination of rapeseed at different temperatures.

	Temperature							
	2	3	5	7	9	15	21	25°C
<u>B. campestris</u> (all genotypes)	34*	67*	88*	78*	90	95*	90*	70*
<u>B. napus</u> (all genotypes)	91	94	96	88	90	91	94	91
<u>B. campestris</u>								
Torch	51b	75b	90b	85b	94b	99b	91a	77a
Candle	23a	57a	83a	67a	82a	91a	86a	65a
S76-4478	30a	69b	90b	81b	94b	96b	91a	69a
<u>B. napus</u>								
Altex	92a	95b	94a	90b	89a	90ab	97b	90a
75G-908	92a	97b	97ab	93b	91a	95b	97b	92a
74G-1382	89a	95b	96ab	87b	95a	92ab	92ab	91a
Regent	89a	89a	92a	76a	85a	87a	91a	88a
Midas	94a	94ab	99b	92b	89a	88a	95ab	92a

*-Species means significantly different at $p \leq 0.05$.

b-values in the same column within each species with the same letter are not significantly different, Tukey's Test $p \leq 0.05$.

Table 2. Mean germination time (days) of rapeseed at different temperatures.

	Temperature							
	2	3	5	7	9	15	21	25°C
<u>B.</u> <u>campestris</u> (all genotypes)	13.83*	10.32*	6.42*	4.08*	2.75*	1.49*	0.83*	0.74*
<u>B.</u> <u>napus</u> (all genotypes)	12.70	8.66	5.96	4.21	3.01	1.66	1.03	0.99
<u>B.</u> <u>campestris</u>								
Torch	13.12a	9.98a	6.41a	4.03a	2.74a	1.41a	0.80a	0.71a
Candle	13.45a	10.80b	6.57a	4.24a	2.84a	1.58b	0.83a	0.75a
S76-4478	14.93b	10.16ab	6.27a	3.98a	2.66a	1.48ab	0.86a	0.76a
<u>B.</u> <u>napus</u>								
Altex	11.95a	8.74b	5.89b	4.36b	3.11c	1.70b	1.04a	1.03b
75G-908	13.77b	9.10b	6.32c	4.31b	3.20cd	1.80b	1.01a	1.01b
74G-1382	11.37a	7.98a	5.21a	3.77a	2.58a	1.51a	0.98a	0.85a
Regent	14.70c	9.77c	6.92d	4.66c	3.30d	1.75b	1.09a	1.08b
Midas	11.69a	7.73a	5.44a	3.95a	2.85b	1.55a	1.00a	0.95ab

*-Species means significantlydifferent at $p \leq 0.05$.

a-Values in the same column within each species with the same letter are not significantly different, Tukey's Test $p \leq 0.05$.

Table 3. Selection among *B. napus* genotypes for slow and fast germinators at 2° and 25°C - 1982.

i) Selection at 2°C

Genotype	Mean Fast germinators days	Number of seeds selected	Mean Slow germinators days	Number of seeds selected	Fastest germinators days
7955202B	7.9	31	18.0	24	2.0
7951452B	7.9	23	13.0	23	2.0
8017011	10.5	23	18.0	34	2.0
7951500B	9.5	27	18.8	36	2.0
7955183B	9.5	27	20.0	32	2.0
7989131K	6.2	40	10.6	8	2.0
8057748B	5.6	16	16.5	28	2.0
Andor	9.0	35	11.5	32	2.0
8045849B	7.6	27	11.6	15	2.9
8051727	8.2	21	20.9	16	2.0
791520	8.1	16	15.4	32	5.9

ii) Selection at 25°C

Genotype	Mean Fast germinators days	Number of seeds selected	Mean Slow germinators days	Number of seeds selected	Fastest germinators days
7955202B	0.8	25	1.65	23	0.66
7951452B	0.76	32	1.05	27	0.50
8017011	0.74	20	0.94	26	0.66
7951500B	0.80	33	1.32	20	0.50
7955183B	0.91	27	1.20	36	0.50
7989131K	0.93	28	1.74	40	0.50
8057748B	0.84	32	1.51	32	0.50
Andor	0.69	31	1.35	33	0.66
8045849B	0.83	24	1.40	21	0.71
8051727	0.72	24	1.22	40	0.50
791520	0.77	22	1.40	30	0.71