Brassica vegetables as edible greens in Newfoundland

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Spaner, D. and Lee, D. R. 2001. ***Brassica* vegetables as edible greens in Newfoundland.** Can. J. Plant Sci. **81**: 165–171. *Turnip tops* or *greens*, the early leaves of rutabaga (*Brassica napus* var. *rapifera* L.), are a traditional Newfoundland vegetable. Commercial farmers currently grow and market forage rape (*B. napus* L.) as greens. Our objectives were to determine why forage rape is now grown in preference to other *Brassica* crops and to examine potential greens alternatives. Seed from two cultivars each of three *Brassicas* [rutabaga, forage rape and forage kale (*Brassica oleracea* var. *medullosa* L.)] was used in: 1) a germination study at 5, 10, 15 and 20°C; 2) a growth study at constant temperature regimes of 12 and 18°C; 3) a 2 yr agronomic study; and 4) a sensory evaluation for appearance and taste as a boiled vegetable. Hobson rape, Dwarf Essex rape and the locally bred Brookfield rutabaga germinated, emerged and grew faster than both kale cultivars and Laurentian rutabaga at all controlled-temperature regimes. The two kale cultivars and Laurentian rutabaga did not exhibit adequate agronomic potential. Although the rape cultivars were among the top-yielding entries at most harvests, Brookfield rutabaga yielded greater leaf weight in both years of the agronomic study. Judges preferred the visual appearance of greens with dark green leaves, a characteristic of the forage rape cultivars studied, but favored the taste of boiled kale.

Key words: Forage rape, kale, rutabaga, SPAD chlorophyll meter

Spaner, D. et Lee, D. R. 2001. **Utilisation des parties vertes des *Brassica* comme légumes à Terre-Neuve.** Can. J. Plant Sci. **81**: 165–171. Les *Turnip tops ou greens*, les premières feuilles du rutabaga (*Brassica napus* var. *rapifera* L.) sont un légume traditionnel à Terre-Neuve et on en produit effectivement pour la vente commerciale. Nous avons cherché à savoir pourquoi ce type de navet se cultive pour cet usage plutôt que d'autres *Brassica* et nous avons examiné des cultures de remplacement éventuelles. Nous utilisons des semences de deux cultivars de chacune de trois espèces de *Brassica* : rutabaga, colza fourrager et chou fourrager (*B. oleracea* var. *medullosa* L.), 1) dans un essai de germination à 5, 10, 15 et 20 °C; 2) dans un essai de croissance en régime thermique constant de 12 ou de 18 °C; 3) dans une étude agronomique de deux ans et 4) dans une évaluation sensorielle de l'aspect et du goût en légume cuit. Dans tous les régimes thermiques comparés, les deux cultivars de navet, Hobson et Dwarf Essex et la variété de rutabaga de sélection locale Brookfield germaient, levaient et poussaient plus rapidement que l'autre variété de rutabaga (Laurentian) et que les deux cultivars de chou fourrager. Ces trois derniers n'ont pas fait montre de possibilités agronomiques satisfaisantes. Bien que les cultivars de navet se soient établis comme les plus producteurs à la plupart des récoltes, c'est le rutabaga Brookfield qui a fourni le plus grand poids de feuilles dans les deux années d'observation agronomique. Les membres du jury de dégustation avaient une préférence visuelle pour la couleur vert foncé, caractère du feuilles des navet fourrager à l'état cru, mais en cuisson, ils préféraient le goût du chou fourrager bouilli.

Mots clés: Navet fourrager, chou fourrager, rutabaga, chlorophyllomètre SPAD

In Newfoundland, rutabaga or swede turnip (*Brassica napus* var. *rapifera* L.) has traditionally been densely seeded and thinned at the two- to four-leaf stage. Such thinned leaves (turnip tops) were the first cultivated vegetable consumed in the summer. Although agriculture in Newfoundland has changed considerably in the past 30 yr, the local diet still retains a traditional core. From early June until the end of summer, locally grown *turnip tops*, *turnip green*s or *greens* are marketed throughout the province in 1 kg polyethylene bags. Commercial farmers can make up to \$30 000 ha^{-1} growing greens for the local market (NF Dept. Fisheries, Food and Agriculture unpublished data). Currently, commercial farmers almost invariably grow forage rape (*B. napus* L.) for the greens market.

Kunelius and co-workers compared the effect of seeding and harvest date on the yield and composition of forage rape and forage kale (*B. oleracea* var. *medullosa* L.) in the Maritimes (Kunelius et al. 1987, 1989; Kunelius and Sanderson 1989). In those studies, the crop was harvested in one late-season cut for animal feed. Some physiological studies have examined the effect of temperature, cultivar and species on *Brassica* seed germination and growth (Acharya et al. 1983; Denton and Whittington 1976; Paul

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Abbreviations: **DAP**, days after planting

Table 1. ***Brassica*** **genotypes selected for investigation**

Cultivar	Crop	Species	Characteristics
Brookfield	Rutabaga	*B. napus* var. *rapifera* L.	Newfoundland-developed cultivar with elevated level of clubroot resistance and green-topped roots; marketed for the table trade in Newfoundland
Thompson Laurentian	Rutabaga	*B. napus* var. *rapifera* L.	Improved strain of Laurentian, originally developed in Quebec in the 1930s, widely grown in eastern Canada
Dwarf Essex	Forage rape	*B. napus* L.	Forage rape variety grown in the Atlantic provinces, with good early-season performance
Hobson	Forage rape	*B. napus* L.	Marketed as a replacement for Dwarf Essex; recommended for early seeding, this variety is reported to be high yielding
Prover	Kale	*B. oleracea* var. *medullosa* L.	Improved forage marrow stem variety with good resistance to frost
Grüner Angeliter	Kale	*B. oleracea* var. *medullosa* L.	Popular Atlantic forage marrow stem variety; stands well in dry weather and is not affected by light frosts

1992; Proudfoot 1983). There have been, however, no agronomic or physiological studies examining *Brassica* crops, or varietal cultivars, specifically eaten as a leafy green cooked vegetable in northern North America.

Our main objective was to determine the physiological and agronomic basis of the commercial preference for forage rape over other potential *Brassica* crops in Newfoundland. In designing experiments to fulfill this objective, our main hypothesis was that forage rape cultivars germinate, emerge and grow faster than other *Brassica* crops in cool temperatures common to Newfoundland in May, June and July. An additional objective was to compare the potential of currently available rutabaga, forage rape and forage kale cultivars for greens production in the Atlantic region of Canada.

MATERIALS AND METHODS

Germination Study of *Brassica* Cultivars

Seed from five *Brassica* cultivars (Table 1 excluding Grüner Angeliter) was germinated in dark growth chambers at four temperatures: 5, 10, 15 and 20°C. Fifty seeds of each cultivar were placed on two filter papers (Whatman # 1) in 10 cm diameter plastic petri dishes and wetted with distilled water. There were four petri dish samples per cultivar × temperature combination, with the resulting 20 dishes arranged in a completely random design within each growth chamber. Seeds were assumed to have germinated when radicles emerged. Germinated seeds were counted and removed from the petri dishes every day for 2 wk. The entire experiment was repeated.

Cumulative percentage germination was analysed for all five cultivars within a single nonlinear model at each temperature (Freund and Littell 1991; Torres and Frutes 1990; Shafii et al. 1991):

$$y = M / (1 + ((M - m) / m)\, e^{-\beta d})$$

where y is the cumulative percentage germination at day d, M is the theoretical maximum of y, m is the theoretical minimum of y, and β is the rate of increase in y. Such a model allows for the testing of cultivar differences for maximum percentage germination and germination rate (increase in y over time), through the comparison of confidence intervals of cultivar-specific parameter estimates. Determination of appropriate models was facilitated within the NLIN procedure of SAS (Freund and Littell 1991).

Growth Study of *Brassica* Cultivars

Six *Brassica* cultivars (Table 1) were grown in two environments: 12°C and 18°C constant day/night temperatures. The day length was 16 h and the photosynthetic photon flux at soil level, from grow- and incandescent-light irradiation, was 12 μmol m^{-2} s^{-1}. Fifteen seeds were planted in plastic pots (25 cm deep × 15 cm diameter) filled with Pro-Mix and subsequently thinned to seven plants per pot. Pots were watered without fertilization until 7 d after emergence and then with a water solution containing 0.5 g L^{-1} 20-20-20 (N-P_2O_5-K_2O) fertilizer. Seven plants (one pot) per cultivar × temperature combination were harvested at 14 d intervals until 56 d after planting (DAP). Pots were arranged in a completely random design within each growth chamber. The entire experiment was repeated.

The number of days from planting to emergence (over 90% of planted seeds emerged) and mean plant weight per pot was recorded. At each harvest, the average number of true leaves of all plants, and the mean length and width of the largest true leaf on three randomly chosen plants, from each pot was recorded.

In preliminary analyses, data were analyzed in a split-split-split plot design, with temperature considered the main plot, cultivar the sub-plot and harvest date the sub-sub-plot unit. There were significant ($P < 0.05$) temperature × cultivar interactions for some traits, and differences ($P < 0.05$) were evident between regression slopes for cultivars at the two temperature treatments (data not shown). For clarity in presentation, we chose to present cultivar mean values interpreted through analysis of variance (SAS Institute, Inc. 1989) at each temperature × harvest date combination. Leaf number per plant data were analyzed following square root transformation (Steel and Torrie 1980).

Agronomic Evaluation of *Brassica* Greens

Brassica greens agronomic yield trials were planted in early June in both 1998 and 1999 at the Atlantic Cool Climate Crop Research Centre near St. John's (47°31′N; 52°47′W). Mean June and July air temperatures were 13 and 17°C in 1998, and 13 and 16°C in 1999. Mean June and July soil temperatures were 12 and 16°C in 1998, and 15 and 18°C in 1999. Total monthly precipitation (mm) was 44 (June) and 98 (July) in 1998, and 49 (June) and 70 (July) in 1999. The 30 yr normals for air temperature are 11 (June) and 16°C (July), with 94 (June) and 78 (July) mm of precipitation (Environment Canada station data, St. John's CDA).

Soils were of the well-drained Cochrane series (Orthic Humo-Ferric Podzol) formed on a gravelly medium-textured glacial till (Heringa 1981). Plots consisted of two 5-m rows spaced 20 cm apart. Seeding was done manually, and plants were thinned by hand to an approximate interplant spacing of 1 cm. Fertilizer (8-24-16 [N-P_2O_5-K_2O] + B[2 %]) was broadcast and incorporated at a rate of 100 g m^{-2} immediately prior to planting. Plots were harvested using hand shears four times during the growing season, when leaves were between 7 and 10 cm long. Topdress nitrogen was manually broadcast as ammonium nitrate (34-0-0) at a rate of 25 g m^{-2} following each harvest. Weeds were controlled manually.

The six *Brassica* cultivars (Table 1) were randomized at planting into two complete blocks in 1998 and three complete blocks in 1999. Data were recorded on a whole plot basis for fresh weight marketable leaf yield. SPAD-502 chlorophyll meter measurements (Watanabe et al. 1980) were recorded just prior to each harvest. Measurements were taken on the latest emerged true leaf, and the mean value from 20 randomly chosen plants per plot was recorded. SPAD readings, which are a measure of relative greenness, range from 0 to 80 SPAD values and are proportional to leaf chlorophyll (Watanabe et al. 1980). Data were analyzed by analysis of variance (SAS Institute, Inc. 1989).

Sensory Evaluation of *Brassica* Greens

In 1999, leaf samples from three cultivars (Thompson Laurentian rutabaga, Dwarf Essex forage rape and Grüner Angeliter kale) were compared for sensory attributes including uncooked color, uncooked appearance and taste after cooking. These three cultivars were chosen because they represent the most common locally grown cultivar of the three respective crops. Representative marketable leaf samples were sampled from the first harvest of the agronomic evaluation and stored (following weighing) at 4°C. Qualitative descriptive analysis (Shamaila et al. 1992) was used for sensory evaluation on the day after harvest. Approximately 500 g of uncooked greens per cultivar was evaluated for color and appearance. A greater quantity of leaves from each cultivar was boiled in unsalted tap water for 5 min and evaluated for taste. Twenty-eight judges scored each attribute for the coded samples by marking a position along an unstructured 10 cm horizontal line scale. Each line was anchored at the ends with the words "poor" and "excellent". Results were quantified by measuring the distance from zero (poor) to the vertical line. Data were analysed by analysis of variance with cultivar means separated by single degree of freedom contrasts (SAS Institute, Inc. 1989).

RESULTS

Germination Study of *Brassica* Cultivars

Germination was very low at 5°C (Fig. 1). Two weeks after planting Thompson Laurentian rutabaga and Prover kale had not germinated, while Hobson rape had the highest ($P < 0.10$) germination of only 6%. Germination curves are not presented at this temperature as these data did not conform ($P > 0.10$) to a nonlinear model.

The nonlinear model provided good descriptions of *Brassica* cultivar germination over time at 10, 15 and 20°C (Fig. 1; Table 2). All cultivars reached a maximum cumulative germination near 100% at 10, 15 and 20°C, except Dwarf Essex, which was near 85% at all three temperature regimes (Fig. 1; Table 2). Maximum germination percentage ± 5% was attained for all cultivars by day 8 at 10°C, day 5 at 15°C and day 3 at 20°C. There were differences among the cultivars for the rate of germination at the three temperature regimes. At all temperatures Thompson Laurentian had the lowest, Prover second lowest and Brookfield, Hobson and Dwarf Essex had consistently high germination rates (Table 2).

Growth Study of *Brassica* Cultivars

There were differences among the cultivars for days to emergence at both 12 and 18°C (data not presented). At 12°C Grüner Angeliter had the longest, Thompson Laurentian the second longest and Brookfield, Dwarf Essex, Hobson and Prover the shortest interval between planting and emergence. Cultivar × temperature interaction was not significant ($P > 0.10$), and the cultivar ranking at 18°C was the same as at 12°C. On average, cultivars emerged 4 d earlier when grown at 18°C than when grown at 12°C.

At a constant day/night temperature regime of 12°C, the six cultivars had grown very little by day 14 and there were no differences ($P > 0.10$) for any trait (Fig. 2). At 28 DAP at 12°C, there were differences ($P < 0.10$) among the cultivars for all traits except leaf number (data for leaf width and length not presented). The two forage rape cultivars (Hobson and Dwarf Essex) had longer and wider leaves with greater plant fresh weight than all other cultivars for that harvest. Differences among cultivars 42 DAP were evident only for the number of leaves per plant. Dwarf Essex rape had the most and Grüner Angeliter kale the fewest leaves at that harvest date. Brookfield rutabaga had the most and Grüner Angeliter kale the least number of leaves 56 DAP at 12°C. Hobson rape and Brookfield rutabaga had the longest leaves and the greatest plant fresh weight, while Hobson, Brookfield and Prover kale had the widest leaves by day 56.

At a constant day/night temperature of 18°C, the six cultivars all grew much faster than at 12°C (Fig. 2). There were

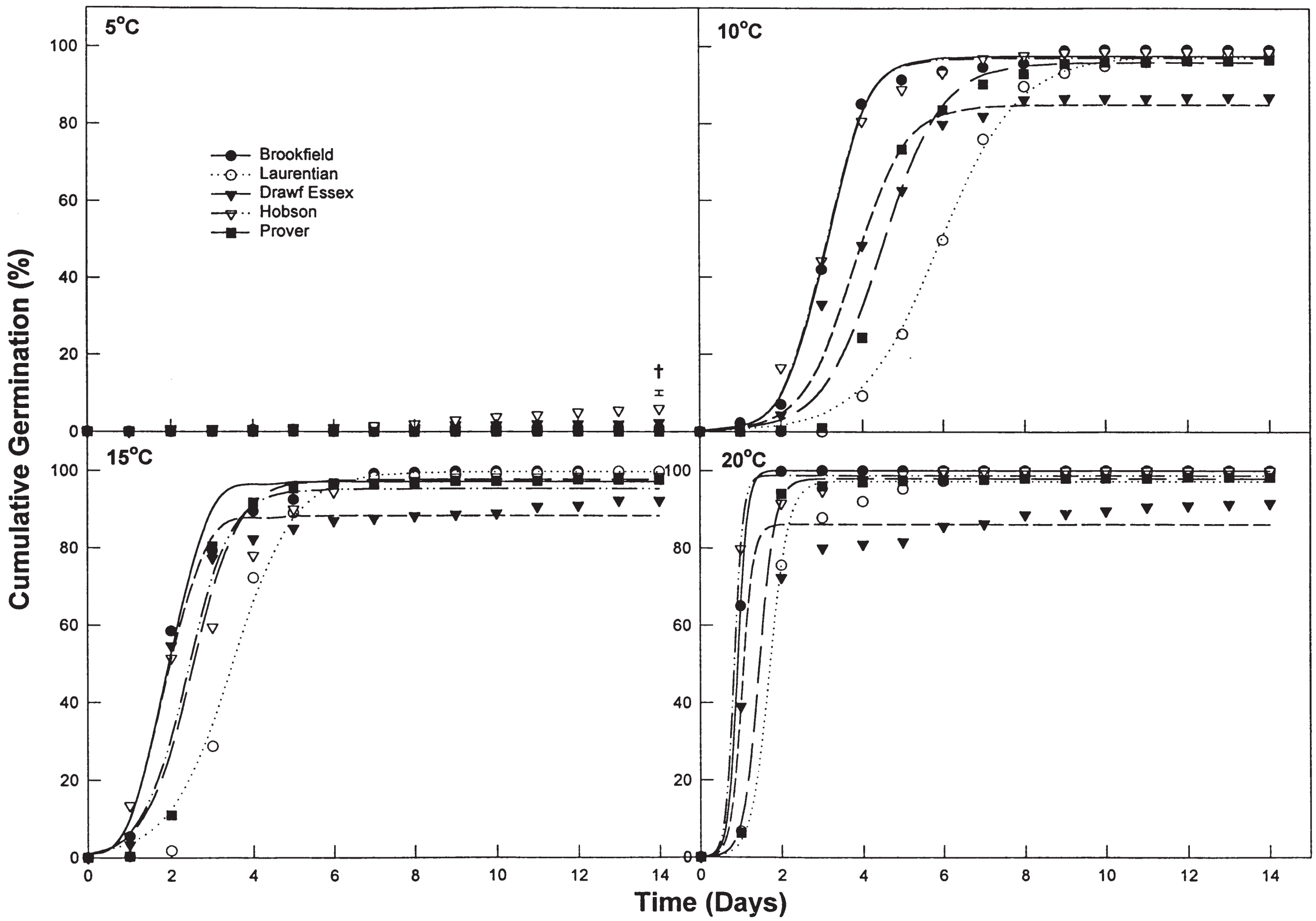

Fig. 1. Cumulative germination percentage of five *Brassica* cultivars as a function of time at 5, 10, 15 and 20°C. Symbols represent experimentally derived mean values, while lines (for 10, 15 and 20°C) represent nonlinear prediction models with parameter estimates given in Table 2. Germination data for 5°C were not modelled. Means differed († indicates $P > 0.10$) on day 14 at 5°C. At that temperature the bar above the symbols represents the interval inherent in the standard error of the difference of two means as determined through analysis of variance.

Table 2. Parameter estimates ± 95% confidence intervals for percentage seed germination of five *Brassica* cultivars as a function of time at 10, 15 and 20°C

			Parameter estimates[z]	
Temperature	Cultivar	Crop	Maximum % germination (M)	Germination rate (β)
10°C	Brookfield	Rutabaga	98 ± 2.6	2.0 ± 0.24
	Thompson Laurentian	Rutabaga	98 ± 3.5	1.0 ± 0.13
	Dwarf Essex	Forage rape	85 ± 3.2	1.6 ± 0.21
	Hobson	Forage rape	97 ± 2.6	2.0 ± 0.25
	Prover	Kale	96 ± 3.4	1.4 ± 0.17
15°C	Brookfield	Rutabaga	97 ± 2.4	2.4 ± 0.32
	Thompson Laurentian	Rutabaga	100 ± 2.8	1.3 ± 0.17
	Dwarf Essex	Forage rape	88 ± 2.8	2.4 ± 0.35
	Hobson	Forage rape	95 ± 2.5	1.9 ± 0.25
	Prover	Kale	98 ± 3.0	1.8 ± 0.25
20°C	Brookfield	Rutabaga	100 ± 1.1	8.0 ± 1.17
	Thompson Laurentian	Rutabaga	97 ± 1.2	4.3 ± 0.60
	Dwarf Essex	Forage rape	86 ± 1.3	7.1 ± 1.17
	Hobson	Forage rape	99 ± 1.1	8.8 ± 1.18
	Prover	Kale	98 ± 1.3	5.1 ± 0.86

[z]Parameter estimates derives from the nonlinear model $y = M / (1 + ((M - m) / m)\, e^{-\beta d})$, where y is the cumulative percentage germination at day d, M the theoretical maximum of y, m the theoretical minimum of y, and β the rate of increase in y.

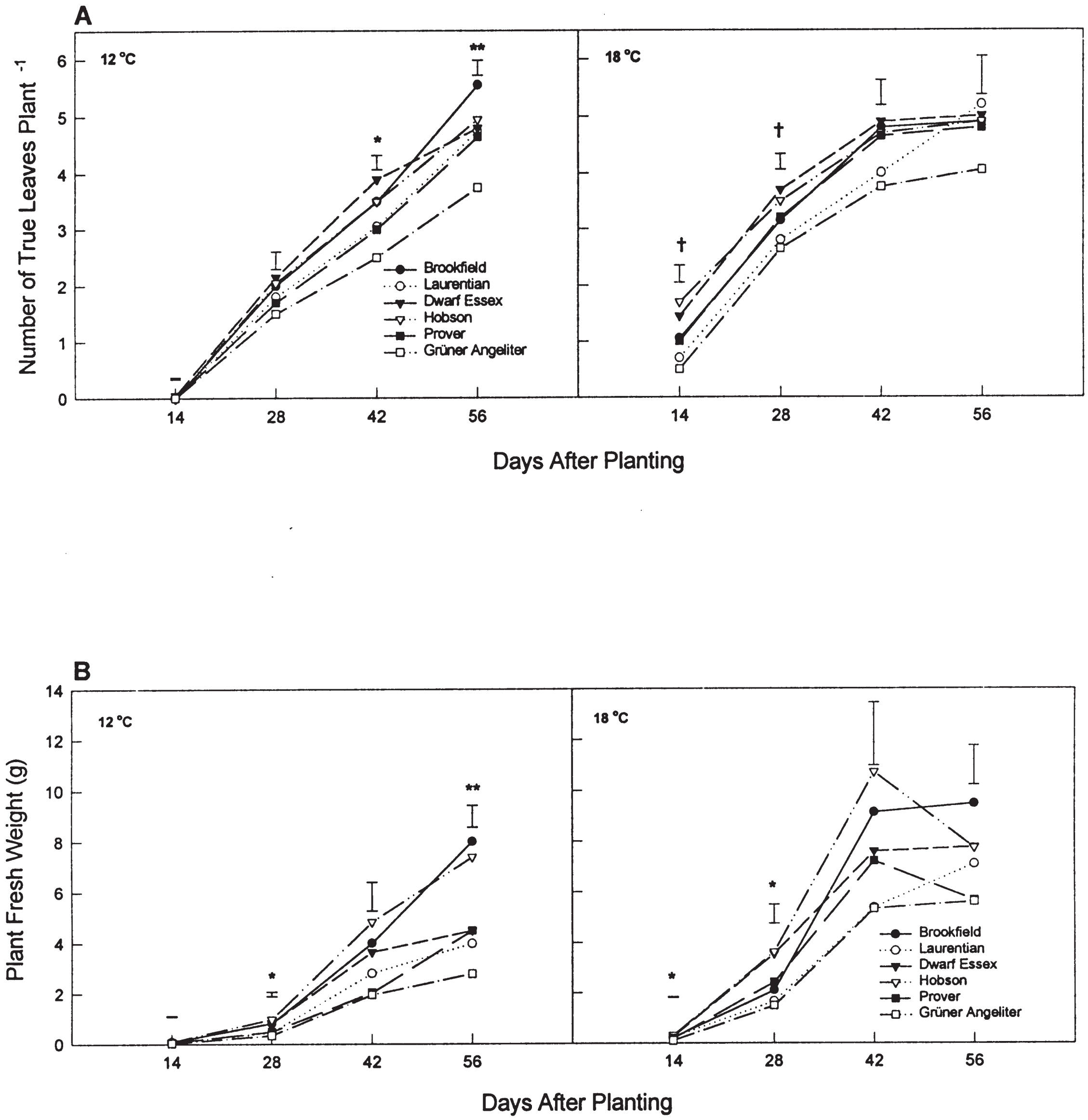

Fig. 2. The number of true leaves per plant (A) and plant fresh weight (B) at 14, 28, 42 and 56 d after planting for six *Brassica* cultivars grown at constant day/night temperatures of 12 and 18°C. Bars above symbols represent the intervals inherent in the standard error of the difference of two means as determined through analysis of variance. The absence of an asterix or a †, * , ** above the error bar indicates no differences among presented mean values ($P > 0.10$), or differences at $P < 0.10$, $P < 0.05$ and $P < 0.01$, respectively.

differences among the cultivars for all recorded traits for harvests 14 and 28 DAP at 18°C. Growth rate comparisons among the six cultivars were almost identical to the 12°C environment. The two forage rape cultivars, Hobson and Dwarf Essex, again had longer, wider and more leaves than all other cultivars for harvests 14 and 28 DAP. They also had greatest plant fresh weights. By 42 DAP at 18°C, all cultivars had grown beyond what could be marketed as greens and also began to have interplant competition within the pots.

Agronomic Study of *Brassica* Greens

Yields were greater in 1998, possibly due to the lower precipitation in 1999, which resulted in periods of drought stress during that year. The cultivars took longer to regrow following harvests in 1999, resulting in differential harvest dates over the 2 yr. Year × cultivar interactions were significant ($P < 0.10$) and differences among cultivars were determined for all harvests (Table 3). There was, however, little variation in cultivar rankings for marketable yield over the eight harvests. The two kale cultivars ranked last, or second last, for 13 of 16 cultivar × harvest combinations. The two forage rapes and Brookfield rutabaga ranked either first, second or third for 22 of 24 cultivar × harvest combinations.

SPAD measurements were analyzed over the 2 yr, by harvest (data not presented). Cultivar × year interactions were significant only for the fourth harvest ($P < 0.05$). Dwarf

Table 3. Mean *greens* yield for six *Brassica* cultivars at four harvest dates in 1998 and 1999

Cultivar	Crop	Greens harvest (days after planting) First (34)	Second (43)	Third (50)	Fourth (60)	Year total
		Fresh weight (kg m^{-2})				
1998						
Brookfield	Rutabaga	2.3	0.9	0.5	1.2	5.0
Thompson Laurentian	Rutabaga	1.1	0.3	0.6	1.0	2.9
Dwarf Essex[z]	Forage rape	2.5	0.8	0.7	1.1	4.3
Hobson	Forage rape	1.4	1.0	0.8	1.2	4.3
Prover	Kale	0.5	0.2	0.3	0.4	1.4
Grüner Angeliter	Kale	0.4	0.1	0.3	0.4	1.1
Cultivar (C) *F*-test		**	*	*	*	**
SE diff.		0.33	0.22	0.09	0.16	0.32
1999						
		(34)	(50)	(63)	(76)	
Brookfield	Rutabaga	0.8	0.7	1.0	0.4	2.9
Thompson Laurentian	Rutabaga	0.5	0.3	0.4	0.1	1.3
Dwarf Essex	Forage rape	0.6	0.5	0.5	0.3	1.9
Hobson	Forage rape	0.8	0.5	0.7	0.3	2.3
Prover	Kale	0.3	0.5	0.5	0.3	1.4
Grüner Angeliter	Kale	0.2	0.3	0.5	0.1	1.1
Cultivar (C) *F*-test		**	**	†	*	**
C × year *F*-test		**	**	†	**	**
SE diff.		0.11	0.06	0.17	0.09	0.30

**, *, † Cultivar *F*-test significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively.
[z]SE diff. for comparisons involving this cultivar in 1998 are 202 g m^{-2} for the fourth harvest and 409 g m^{-2} for the 1998 year total, as there was a missing value in the fourth harvest of that year.

Essex forage rape and Prover kale had the greenest leaves and the two rutabaga cultivars had the least green leaves for the first three harvests.

Sensory Evaluation of *Brassica* Greens

Judges discerned differences among the cultivars for the three sensory attributes studied (Table 4). For both uncooked color and appearance, they preferred Dwarf Essex forage rape over Grüner Angeliter kale, and ranked Thompson Laurentian rutabaga last. For taste, however, the judges preferred the kale cultivar and ranked the forage rape cultivar last.

Table 4. Mean values for the sensory attributes of uncooked color and appearance, and cooked (boiled) taste, for three *Brassica* vegetables in 1999[z]

Cultivar	Crop	Uncooked Color	Uncooked Appearance	Cooked Taste
Thompson Laurentian	Rutabaga	6	5	6
Dwarf Essex	Forage rape	8	8	5
Grüner Angeliter	Kale	7	7	7
Cultivar *F*-test		**	**	†
SE diff.		0.5	0.5	0.7
Contrasts				
Forage rape vs. Kale		*	*	*
Forage rape vs. Rutabaga		**	**	NS
Kale vs. Rutabaga		*	**	NS

NS, **, *, † Cultivar *F*-test (or contrast) not significant, and significant at $P < 0.01$, $P < 0.05$ and $P < 0.10$, respectively.
[z]Terms anchoring the line scales were (0–10) poor–excellent.

DISCUSSION AND CONCLUSIONS

There was little evidence of cultivar × temperature interaction for germination, emergence and early plant vigor among the six *Brassica* cultivars we studied here. Forage rape and forage kale differed for these traits, and we found large differences between two cultivars of rutabaga. The two forage rape cultivars and Brookfield rutabaga germinated faster, grew faster in constant temperature environments (between 10 and 20°C) and had higher yields in the field (where mean monthly air temperatures ranged from 13 to 17°C) than the two kale cultivars and Laurentian rutabaga. Brookfield was bred in Newfoundland, and it is evident that early-season vigor in cool climates has been incorporated into this cultivar through local selection.

Oilseed canola/rapeseed (*Brassica napus* L.) possesses limited variability for germination and seedling vigour at low temperatures (Acharya et al. 1983), while rutabaga cultivars vary for germination rates at low temperatures (Proudfoot 1983) and for plant growth (Denton and Whittington 1976). Rutabaga cultivar × temperature interactions have previously been noted for growth rates (Denton and Whittington 1976), but the lack of interactions has also been reported for emergence in oilseed rape (Squire 1999).

Given the results of our studies, it may be agronomically rational for Newfoundland growers to consider using Brookfield rutabaga for greens production, or to explore the potential of other locally bred rutabaga varieties. There was no apparent yield difference between the two forage rape cultivars we studied. Cultivar choice among currently available forage rapes would simply be a question of grower preference, or seed availability, if yield were the only consideration. Our sensory evaluation indicated that consumers prefer greens cultivars with dark green leaves. Rutabaga cultivars had the lightest green leaves and this may be a drawback for the greens potential of Brookfield. Dwarf Essex forage rape had darker green leaves than Hobson, and this characteristic could be taken into consideration by Newfoundland producers. Although judges in our taste test preferred kale, the two kale cultivars did not yield well enough for consideration as a greens alternative in Newfoundland.

ACKNOWLEDGMENTS

Many thanks to Emily Doyle and Todd Reid for technical assistance. Thanks to P. Dixon and B. Penney for reviewing the manuscript. Supplementary funding assistance was provided by Agriculture and Agri-Food Canada Matching Investment Initiative funding agreements with the Newfoundland and Labrador Federation of Agriculture and the Newfoundland Horticulture Council.

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