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EVALUATION OF SPRING MILLING WHEAT CULTIVARS FOR ORGANIC PRODUCTION AT SPEERVILLE, DEBEC, AND CAMBRIDGE-NARROWS, 1998

ÉVALUATION DE CULTIVARS DE BLÉ DE MOUTURE DE PRINTEMPS POUR UNE PRODUCTION DE TYPE BIOLOGIQUE À SPEERVILLE, DEBEC ET CAMBRIDGE-NARROWS, 1998

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Abstract: Yield goals of 1.7 to 2.2 T ha^{-1} and protein quality targets of 13.5% or more were achieved in 1998 spring milling wheat organic cultivar trials carried out in three locations. Wheat yields ranged from 1.0 to 2.4 T ha^{-1} in replicated cultivar trials. Percent protein in replicated trials ranged from 11.52 to 17.41%, with most results above 13.5%. The most significant differences in weed and disease pressure were found between locations rather than between cultivars. Initial evaluations show that it is likely other cultivars as good or better than Roblin will be identified over the three year trial period.

Résumé : Des essais de cultivars biologiques de blé de mouture de printemps ont été réalisés à trois endroits en 1998, et les buts ont été atteints en ce qui concerne le rendement (de 1,7 à 2,2 t/ha) et la teneur en protéines (13,5 % ou plus). Les rendements variaient de 2,4 à 1,0 t/ha dans les essais répétés. La teneur en protéines variait de 11,52 à 17,41 %, et elle était supérieure à 13,5 % dans la plupart des cas. En ce qui concerne l'envahissement par les mauvaises herbes et les maladies, l'écart était plus significatif d'un endroit à l'autre que d'un cultivar à l'autre. Les premières évaluations indiquent que l'on trouvera probablement d'autres cultivars aussi bons que le Roblin durant la période d'essais de trois ans.

Introduction

The demand for locally-grown and organically-grown grains for human consumption has increased dramatically in the 1990s to the point where much of the product has to be imported into the region. A degree of success in growing and processing locally-grown grains has been achieved in New Brunswick, and the industry is ready to grow. One limitation identified by farmers wishing to grow the grains is that available cultivars may not necessarily be the best ones for

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either New Brunswick conditions or organic farms. This is because, for the most part, they are selected in Western Canada, under conventional management. Farmers were keen to collaborate in selection trials that could identify more appropriate cultivars. In 1998 three certified organic wheat growers hosted wheat cultivar trials. We also grew flax, millet, grain corn, and confection sunflower seeds in demonstration plots at one of the locations.

It has been demonstrated that local producers have the potential to fill the demand in the region (Walker and Smith, 1989). Farmers, N.B.D.A.R.D. staff, and other researchers, have identified the need for varieties of milling grains suited to NB/organic growing conditions (Walker and Smith, 1989-1992; William Brinton, *personal communication*). At the same time, millers have identified the need for adequate quality of product for processing.

Yield and quality of bread wheat. Improving the yield and quality of grains for milling are important factors in this trial. In the case of bread wheat, farmers are interested in getting higher yields and better competition with weeds than they do now. In conventional systems, yields of 3.4 to 4.5 T ha^{-1} are desirable but difficult to achieve with the presently used Roblin cultivar (Speerville Mill conventional farmer's meeting, Feb. 16, 1998). In organic systems, yields of 1.7 to 2.2 T ha^{-1} are desirable, but commonly about 1.1 T ha^{-1} is achieved with Roblin. Roblin also does not tiller, which is a characteristic sought for helping with weed competition in organic systems. Protein levels of 13.5% or more as well as good baking qualities are the goal for millers who buy the wheat from farmers. It is important when seeking higher-yielding varieties, that they also achieve the quality standards required for commercial mills.

Yields and quality can be improved by cultivar selection, crop management, as well as favourable weather conditions such as dry summer weather (Dormaar *et al.*, 1997; Debaeke *et al.*, 1996). While the weather cannot be controlled, both improved management and selection of appropriate varieties can help to improve yield and quality.

Cultivars. The cultivars chosen for the trial include Roblin as well as those that are presently being recommended such as AC Walton, AC Barrie, and Grandin. Cultivars such as Teal, Park, 'Speer' and Huron that are presently being used and saved by organic farmers were included in the trial. In addition, several 'heritage' varieties (those developed prior to 1950) were included in replicated and non-replicated trials based on seed availability. Heritage varieties such as Huron, Selkirk, and Acadia are included in the trial because they showed promise during the period when bread wheat was grown extensively in the Maritimes (Nappan Experimental Farm Progress Report, 1953-57; Fredericton Experimental Farm Progress Report, 1953-57; Dr. Hans Nass, *personal communication*). Other heritage varieties are included because they may contain useful characteristics that could be used in breeding programs. The categories of wheat varieties used in the 1998 trial, which often overlap, are shown in Table 1.

It has been demonstrated that cultivars that do well in organic systems often have different yield rankings than those that do well in conventional systems (Lampkin, 1990; Poutala *et al*., 1993; Stöppler, 1988). This is not surprising since on organic

Table 1. Categories of spring wheat cultivars used in the 1998 organic trial.

Modern varieties	Varieties favoured by organic growers	Varieties developed in the Maritimes	Heritage varieties
AC Barrie [RS,D,C] Grandin [RS,D,C] Roblin [RS,D,C] Teal [RS,D,C] AC Walton [RS,D,C]	Coteau [S] Huron [RS] Park [RS] "Speer" [S] Teal [RS,D,C]	Acadia [N] AC Walton [RS,D,C]	Acadia [N] Coteau [S] Huron [RS] Laura [S] Marquis [S] Red Fife [S] Reward [S] Selkirk [S] Thatcher [RS]

[RS] included in replicated trial, Speerville site
[S] included in non-replicated trial, Speerville site, due to initial shortage of seed
[D] included in non-replicated trial, Debec site
[C] included in non-replicated trial, Cambridge-Narrows site
[N] grown out for next year's trials by Dr. Hans Nass, Agriculture Canada

farms, selection criteria (such as competitiveness with weeds or deep roots) and soil management environments are different from conventional ones. Stoppler (1988) found high yields in organic systems are closely related to high above-ground biomass and high straw yields, and that these factors are associated with greater root penetration and development, which is important for the nutrition of the plant and for anchorage where mechanical weed control is used. In organic systems, the short-strawed wheat varieties are also disadvantageous because they leave the crop open, allowing weeds to compete more effectively and because on most organic farms straw is an important raw material (Lampkin, 1990).

Management. In cultivar trials conducted by Walker and Smith (1989-1992) on organic farms in New Brunswick, yields of 2 T ha^{-1} were achieved in an organic system in 1989 with several varieties (Walker and Smith, 1989). On this particular farm, manure was applied prior to sowing the wheat crop, and weed management was good. The grain was planted by May 18. Therefore, it is reasonable to assume that yield goals of 1.7 to 2.2 T ha^{-1} are achievable on organic farms in New Brunswick. Unfortunately, protein and other quality indicators were not reported in these organic trials.

Factors that affect wheat quality. It is suggested by Dormaar *et al*. (1997) that soil quality could have a more dramatic effect on wheat milling and baking

characteristics than cultivar does. For example, increasing soil erosion generally leads to a decline in flour protein content and other baking quality characteristics (Dormaar *et al*., 1997).

Dormaar *et al*. (1997) found that fertility amendments (manure, synthetic fertilizer, and fertilizer plus straw) increased flour protein content of bread wheats relative to controls. However, the type of year in which the wheats were grown had just as much effect on protein levels. Baking quality, however, was found to be largely affected by fertility amendment. In a recent study in France, Debaeke *et al*. (1996) showed that previous crops in the rotation, such as legumes, can positively affect the quality and yield of wheat. However, excessive rates of synthetic N fertilization may negatively alter bread-making quality (Martin and Taurcau, 1992, cited in Debaeke *et al*., 1996).

Total protein of wheat does not necessarily have predictive value in terms of milling and baking quality characteristics. Dough strength, for example, is not linearly dependent on protein content but rather is a measure of inherent quality (Lukow, 1991). "It is the *quality* of the wheat, i.e. the quantity and type of amino acids that make up the total protein, that helps establish the effect of erosion and amendment on wheat quality" (Dormaar *et al*., 1997:29).

Materials and Methods

Speerville site, Stu Fleischhaker's farm. Eight spring wheat cultivars (AC Barrie, Grandin, Huron, Park, Roblin, Teal, Thatcher, and AC Walton) were planted in 3 x 15m plots with three replicates in a randomized complete block (RCB) design on May 13 using a plot seeder at a rate of 168 kg ha^{-1}. Five additional varieties (Laura, Marquis, Reward, Selkirk, and Speer) were planted (on the same day and using the plot seeder) in smaller plots (1 x 15 m) beside the replicated trial for preliminary observation and seed increase. The same seeding rate of 168 kg ha^{-1} was used. In an adjacent field, one wheat cultivar (Coteau) was established by hand broadcasting and subsequent rolling, for seed increase and preliminary observation on May 28. Confection sunflowers, grain corn, flax, and two varieties of millet were also established using a two-row hand seeder and hand broadcasting, adjacent to the Coteau wheat on May 28. These were for preliminary observation and processing tests. Very small quantities of two additional varieties, Acadia and Red Fife, were planted for seed increase.

The field where the first 13 wheat varieties mentioned above were planted (Field 1S) was manured, plowed, harrowed, and seeded to ryegrass in 1997. In the fall of 1997, the ryegrass was grazed. On May 1, 1998, the field was plowed, with subsequent harrowings occurring on May 10, 11, and 12. Although the field was not evenly dry or adequately prepared, seeding occurred on May 13. No additional fertility or amendments were applied. The soil is a loam. A soil sample taken at seeding indicated an organic matter content of 5.5%, pH of 5.5, low

phosphorous, medium calcium and potassium, and adequate magnesium. The field where the Coteau wheat was planted (Field 2S), also a loam, was manured and plowed from pasture in early May. The soil sample analysis was very similar to field 1S. It was considered to be adequately prepared before planting.
Various evaluations of crop seedlings, weeds, and disease were carried out throughout the summer. These observations were made at a fixed location 3 meters from the east edge of each plot, using a 50 x 50 cm quadrat. Samples were taken for disease and biomass evaluation on the edges of the plots so as not to interfere with yield evaluations. A Hedge plot harvester was used to harvest a 1.5 m strip in the middle of each plot on September 2 for all varieties except Huron and Coteau, which were harvested September 24.

Debec site, William and Joan Flemming's farm. Five milling wheat cultivars (AC Barrie, Grandin, Roblin, Teal, and AC Walton) were established in unreplicated strips 3 m wide and 122 m long at a rate of 168 kg ha^{-1} on May 1. The rest of the field was planted to AC Walton on the same day. An irregularity occurred while seeding the AC Walton and Grandin trial strips. They were seeded more heavily than the other cultivars. Evaluations were done on both the AC Walton in the field adjacent to the strips, as well as the heavily-seeded AC Walton in the trial strip. Data from the field was used when the two differed significantly. Data from the Grandin strip was mostly excluded from any evaluations.

The soil is a sandy loam and high in fertility due to the fishmeal added at the time of seeding and while the field was being prepared in the spring. A soil sample taken at seeding indicated an organic matter content of 4.1%, pH of 5.6, high phosphorous, and inadequate calcium, potassium and magnesium.

Two samples (50 x 50 cm quadrats) of each cultivar were taken August 3 for disease evaluation. Final yield and biomass estimates on September 2-4 were taken from 1 x1 m quadrat samples at two corresponding locations in each cultivar strip and in the adjacent field. The distance into the strip for both of the samples was chosen randomly.

Cambridge-Narrows site, Al and Simone Geddry's farm. Five milling wheat cultivars (AC Barrie, Grandin, Roblin, Teal, and AC Walton) were established in unreplicated strips one seeder width (3m) and 104 m long at a rate of 168 kg ha^{-1} on June 23. The rest of the field was planted to AC Walton on the same day. Prior to seeding, the field was harrowed several times for weed control. After emergence, the field was harrowed once.

The soil is a silty clay loam and high in fertility due to a plowdown of a 1997 crop of soybeans that were not harvested the year before. One tonne of calcitic lime was added in 1997 and another in the spring of 1998. A foliar application of PEI fish fertilizer at the rate of 19 L ha^{-1} was used at the end of the vegetative stage. A

soil sample taken in May indicated an organic matter content of 4.4%, pH of 5.3, medium phosphorous and potassium, with adequate calcium and magnesium.

Disease evaluation was done at harvest because no disease was evident before October. Final yield and biomass estimates on October 7 were taken from 1 x 1 m quadrat samples at two corresponding locations in each cultivar strip and in the adjacent field. The distance into the strip for both of the samples was chosen randomly.

For all locations, milling protein analysis of composite samples (where applicable) was done at the East Coast Commodities lab in Steam Mill, Nova Scotia. The results are adjusted to 14% moisture. Composite samples of the eight replicated varieties were also sent to Dover Mills for quality analysis. At printing, these results were not yet ready.

Results and Discussion

In organic systems, yields of 1.7 to 2.2 T ha^{-1} are desirable, but usually yields of about 1.1 T ha^{-1} are achieved with Roblin. At the Speerville site, where yields were lowest of the three locations, yields of replicated cultivars ranged from 1.0 to 1.6 T ha^{-1} (Table 2). Several cultivars outyielded Roblin. The Huron had some difficulty germinating. Two distinct germinations occurred, one initially and another when it rained again, about a week later. Huron was taller than the other cultivars, while Grandin appeared to be too short to compete with the weeds. This site was very weedy due to inadequate field preparation and lack of post-emergent harrowing equipment. Walton had the highest incidence of glume Septoria, although it was only significantly different from Grandin. Leaf Septoria ratings did not differ among cultivars.

When the results from the three locations are combined, yield goals for organic production are achieved, ranging from 1.6 - 2.0 T ha^{-1} (Table 3). Protein is inversely related to yield in this case, although all cultivars were above the 13.5% target for milling wheat.

Organic producers are looking wheat cultivars that have the ability to compete with weeds. Weed biomass as a percentage of the total biomass (crop and weed) in plots did not differ significantly among the modern varieties evaluated at all three sites (Table 4). No lodging was observed in any of the trials.

When all the varieties are included in the evaluation, despite the fact that they are not all replicated, Speer, Selkirk, Walton, Reward and AC Barrie all demonstrated higher wheat to weed ratios at 7 and 37 days after seeding (Table 5). These were also the highest yielding varieties at the Speerville location. These results must be

interpreted with care because they are not from replicated plots, and seedling vigour is both a function of seed quality as well as of cultivar. In this case, only AC Barrie and Grandin were from certified seed. All of the varieties in the trial at Speerville except Speer and Huron achieved a 13.5% or higher milling protein level. Roblin, Selkirk, Teal and Park appear to be the earliest-maturing varieties,

Table 2. Spring wheat organic cultivar evaluations (at harvest unless otherwise specified), Speerville, N.B., 1998

Cultivar	Seed germination May 10 (%)	Yield (T ha^{-1})	Plant Height (cm)	Spikelets with glume Septoria (%)	Leaf Septoria rating Aug 18 (0-9)
AC Walton	100	1.60 a	83 c	31 a	6 a
AC Barrie	100	1.48 ab	84 c	8 ab	7 a
Park	100	1.25 bc	95 b	23 ab	6 a
Roblin	96	1.21 bc	76 d	6 ab	7 a
Teal	92	1.12 c	84 c	10 ab	7 a
Grandin	76	1.11 c	70 e	3 b	6 a
Huron	20	1.06 c	101 a	27 ab	6 a
Thatcher	88	1.00 c	92 b	19 ab	7 a
LSD (0.05)	--	0.3	4	25	2
CV (%)	--	19.3	15.0	101	13.7

* Means followed by the same letter within each column are not significantly different by LSD test (0.05). LSD is Least Significant Difference, and CV is the coefficient of variation.

Table 3. Spring wheat organic cultivar evaluations at harvest, pooled results from three sites: Speerville, Debec, and Cambridge Narrows N.B., 1998

Cultivar	Yield (T ha^{-1})	Protein (%)	TKW (g)	Plant Height (cm)	Shrivelled kernels (%)	Grain heads per m^2
AC Walton	2.00 a	13.79 a	35.1 ab	80.5 a	13 a	248 b
Grandin	1.87 a	14.24 a	40.3 a	71.5 b	5 a	283 ab
Teal	1.71 a	14.74 a	31.3 b	78.8 a	14 a	260 b
AC Barrie	1.66 a	15.22 a	34.3 b	79.7 a	10 a	362 a
Roblin	1.60 a	15.41 a	33.4 b	74.0 ab	8 a	242 b
LSD (0.05)	0.47	2.24	5.0	6.7	11	99
CV (%)	23.9	12.3	12.0	12.7	58.7	26.4

* Means followed by the same letter within each column are not significantly different by LSD test (0.05).

Table 4. Spring wheat organic cultivar plant biomass evaluations, pooled results from three sites: Speerville, Debec, and Cambridge Narrows N.B., 1998

Cultivar	Total biomass (crop + weeds) (T ha^{-1})	Weed biomass (% of total)	Grain head biomass (% of total)	Straw biomass (% of wheat biomass)
AC Walton	7.57 a	29 a	44 a	38 a
Grandin	6.21 a	28 a	48 a	33 a
Teal	5.73 a	26 a	46 a	31 a
AC Barrie	6.47 a	23 a	48 a	37 a
Roblin	5.54 a	28 a	43 a	39 a
LSD (0.05)	2.27	12.72	11.33	11.51
CV (%)	33.6	78.4	33.4	18.8

* Means followed by the same letter within each column are not significantly different by LSD test (0.05).

Table 5. Spring wheat organic cultivar preliminary evaluations. Data is presented here for 'heritage' or 'saved' varieties, grown at the Speerville site (without replication, due to initial shortage of seed). Data from replicated trials is also included for comparison.

Cultivar	Wheat yield (T ha^{-1})	Wheat protein (%)	Mean wheat / weed seedling ratio		Mean wheat height at harvest (cm)	Maturity ranking (1-green to 10- ready to harvest)
			day 7 after seeding	day 37 after seeding		
						Aug 18
'Speer'	3.40 -	12.23	6.7	5.5	73 -	6
Selkirk	1.81 -	15.23	8.7	7.0	101 -	8
AC Walton	1.60 a	14.10	3.9	3.2	83 c	5
Reward	1.52 -	15.94	4.3	3.4	110 -	6
AC Barrie	1.48 ab	15.90	9.0	4.7	84 c	5
Park	1.25 bc	16.28	2.4	3.6	95 b	7
Laura	1.24 -	15.27	4.3	2.8	87 -	6
Roblin	1.21 bc	15.89	1.5	2.5	76 d	9
Marquis	1.17 -	14.79	0.9	2.3	102 -	5
Teal	1.12 c	15.45	6.8	3.1	84 c	8
Grandin	1.11 c	14.16	1.2	2.3	70 e	6
Huron	1.06 c	13.13	1.4	2.2	101 a	4
Thatcher	1.00 c	15.47	3.7	2.2	92 b	5
Coteau	0.98 -	15.23	--	--	95 -	--
LSD (0.05)	0.29	--	--	--	4	--
CV (%)	19.3	--	--	--	15	--

* Means followed by the same letter within each column are not significantly different by LSD test (0.05). Means followed by dashes were not replicated and therefore not statistically analysed.

which is important to growers in New Brunswick. It is particularly important for farmers wishing to get their crop off before disease sets in, and for those who are not using fungicides.

When all 14 varieties planted at Speerville are included in the comparison, it appears that Walton, Park, and Huron have higher incidence of glume Septoria. Speer, Grandin and Coteau appear less affected (Table 6). Grandin, Park, Thatcher and Coteau all had some fusarium, although these diseases didn't show up in the samples. Thatcher and Coteau had less than 10 heads with take-all, and Coteau, Walton and Grandin had two heads in the plot with loose smut. Walton, AC Barrie and Roblin all had incidences of ergot bodies (data not shown). No generalizations can be made regarding disease incidence in modern vs. older varieties.

It is interesting to separate the data by location (Table 7). Here we see at the Cambridge-Narrows location, where pre- and post-emergence harrowing was possible, and where seeding didn't occur until late in the season when there was less rain, weed pressure was negligible. Even the undersown clover did not begin to emerge until October. The yields were also much higher at this location, although we don't know whether this is a function of the soil fertility, the absence of weeds, or the foliar fish fertilizer application. Wheat height was much shorter at this location, possibly due to day length effects at a younger growth stage. The percentage of total wheat weight occupied by the grain head was higher at this location than any other; at Cambridge Narrows it ranged from 63-70%, whereas at Speerville it ranged from 26-38% (data not shown). Disease pressure was lower at Cambridge-Narrows than the other two locations, possibly due to the slightly different growing season, the foliar feeding, soil condition, or the lack of weeds allowing for good air circulation.

Wheat yields and disease pressure were both higher at Debec than at Speerville. Protein levels were higher at Speerville than Debec. Weed pressure was similar at both Debec and Speerville locations.

Soil nitrate and conductivity measurements (as indicators of soil fertility) throughout the season were comparable at all three locations and showed adequate levels at the three locations (data not shown). The main difference that emerged is at the Cambridge-Narrows site, a greater percentage of the fertility was directed to grain production (versus weeds or straw) than at the other two sites.

Conclusions

Yield goals of 1.7 to 2.2 T ha^{-1} and protein quality targets of 13.5% or more were achieved in 1998 spring milling wheat organic cultivar trials in many cases. Initial evaluations show that it is likely other cultivars as good or better than Roblin will

Table 6. Spring wheat organic cultivar preliminary disease evaluations. Data is presented here for 'heritage' or 'saved' varieties, grown at the Speerville site (without replication, due to initial shortage of seed). Data from replicated trials is also included for comparison.

Cultivar*	Mean number of filled spikelets per head	Spikelets with glume Septoria (%)
'Speer'	30	3
Selkirk	21	15
AC Walton	25	31
Reward	28	16
AC Barrie	28	8
Park	21	23
Laura	40	14
Roblin	23	6
Marquis	n/a	n/a
Teal	25	9
Grandin	21	3
Huron	28	23
Thatcher	24	19
Coteau	37	2

* Cultivars are ranked from highest to lowest yield.

Table 7. Yield, disease and weed pressure of spring wheat cultivars, separated by location, at three sites: Speerville, Debec, and Cambridge Narrows N.B., 1998

Cultivar*	Mean wheat yield (T ha^{-1})	Milling protein (%)	Spikelets with glume Septoria (%)	Weed biomass (% of total)	Wheat height (cm)
Speerville					
AC Walton	1.60	14.10	31	46	83
Grandin	1.11	14.16	3	39	70
Teal	1.12	15.45	6	50	84
AC Barrie	1.48	15.90	8	45	85
Roblin	1.21	15.89	6	52	76
Debec					
AC Walton	1.98	13.87	60	42	93
Grandin	2.11	12.59	n/a	46	82
Teal	2.20	11.52	98	28	84
AC Barrie	1.68	13.17	44	24	87
Roblin	1.69	12.93	72	31	80
Cambridge-N.					
AC Walton	2.43	13.41	7	0	65
Grandin	2.39	15.98	4	0	61
Teal	1.81	17.24	17	0	68
AC Barrie	1.82	16.60	7	0	67
Roblin	1.90	17.41	8	0	66

* Cultivars are ranked from highest to lowest mean yield, for the three locations combined .

be identified over the three year trial period. Next year we hope to include some of the more promising heritage or 'saved' cultivars in replicated trials.

Milling protein levels in organically grown wheats at two locations were very high, particularly at the Cambridge-Narrows location. The most significant differences in weed and disease pressure were found between locations rather than between cultivars. It was informative to establish the trials at three locations in order to appreciate the range of possibilities each cultivar can achieve, and to learn more about organic management of milling wheat.

Preliminary observations on grains other than wheat grown in field 2S at the Speerville site indicated potential for growing flax, millet and sunflower seeds organically. The grain corn had a disappointing yield, however (data not shown). Processing the millet and sunflower seed at the Speerville Mill would require additional investment in equipment, as present equipment for cleaning and hulling are inadequate.

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