B.C. GRAIN PRODUCERS ASSOCIATION

Malt Barley Seeding Rate

(2002 – 2004 Interim Summary)

March 8th, 2005

INTERIM REPORT

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OPENING REMARKS:

The BC Grain Producers Association initiated two agronomic trials in the spring of 2002 in an effort to try and figure out what is needed to help stabilize good malting barley characteristics for malting barley being grown within the Peace River region. Three main inputs that growers have some control over are fertility, disease protection, and seeding rate. It was decided fertility and disease control could be studied together and resulted in the Fungicide x Nitrogen Trial whose three-year interim summary is currently incomplete at this time due to complications during the 2004 harvest. Early snowfall in 2004 compromised some of the data for this particular trial, thus it will be summarized after next year's data is collected which would once again give us a three-year summary for the Fungicide x Nitrogen trial, assuming of course it will be a better year for harvest in 2005. It was decided seeding rates would be best studied as a separate issue as this would limit the number of variables and thus the number of possible interactions. Resulting data for the seeding rate trial was not compromised in 2004 and data was found to be sound for all three years (2002 – 2004).

The information included in this report is a three-year interim summary of results collected thus far. Although conclusions are being suggested in this report, the final conclusions will not be available until after the completion of the remaining two years of this five-year study, (post harvest 2006). Therefore, final conclusions could vary somewhat from those being suggested here in this report, having the privilege of being backed by two more years of data, however the trends in this report are fairly strong and drastic differences are not expected post-interim.

At this point we would like to formally thank our three major sponsors, Investment Agriculture Foundation of British Columbia, Peace River Agriculture Development Fund, and the BC Peace River Grain Industry Development Council (grain levy monies), without their help this type of work would simply be impossible to undertake. In addition to these major funding organizations, matching dollars are raised by contracted work offered to the agricultural community for a fee by the association's research department. This contracted work is also vital as it allows the Association to raise the matching dollars required to attract and satisfy funding requirements of the major funding organizations.

The trials were duplicated at both the Association's North Peace and South Peace research farms. These farms are located just north of the city of Fort St. John and just northeast of Dawson Creek respectively. There was a conscious effort made to repeat these trials at both locations in order to gather more data more quickly, and to study the possible effects of different weather patterns. This proved to be a good idea at least for the years 2003 and 2004, as the north and south Peace regions weather were opposite one another regarding available soil moisture conditions for both these two years. Specifically in 2004, Dawson Creek experienced a significant drought that lasted from before the trials were planted to about early July. This drought in the south had significant impact on the ability of plants to have good fertility uptake and results here will reflect that. A similar but less severe situation was experienced in 2003.

Only those trials that produced good-to-excellent statistical stability are included in this interim report. As discussed above, poor harvest conditions experienced in 2004 did cause the loss of some data for the Fungicide x Nitrogen trial dataset due to unacceptable variability as reflected in the statistical analysis for that trial in 2004. For that reason, this latter trial is not reported here.

INTRODUCTION:

This trial was set up to study the potential response of yield and grain quality of malt barley to an increased seeding rate at plant. After the initial year's work had been undertaken in 2002, other work of a similar nature had coincidently been initiated at the same time in Alberta by Dr. John O'Donovan[1] on non-malt barley and brought attention to a possible influence seeding rate might have on maturity. Thanks to Dr. O'Donovan's investigations[1], maturity data was also included in the trial's data assessment collection package.

Each year that the trial was run and at both locations (North and South Peace), every effort was made to maintain fertility levels to that expected for the production of malt barley in our area.

Two 2-row malt barley lines Harrington, (an old favourite choice by malting companies), and AC Metcalfe, (the newer up and coming replacement for Harrington), plus one 6-row malt barley line B1602, (another old favourite for malting), and one 2-row feed barley line for comparison (CDC Bold), were chosen to thoroughly study the seeding rate issue. Several malt barley lines had to be studied in order to eliminate or expose any possible interaction with "variety" to "seeding rate". The varieties studied here represented one factor in the trial, (called factor A).

The other factor in the study (called factor B) looked at the different seeding rates themselves being used. The seeding rates chosen were: 1.5, 2, 2.25, 2.5, and 2.75 bushels / acre at plant respectively. Each season percent germ and hectolitre weights were found and used to find each unique bushel weight per variety in order to find the individual weights needed per seeding rate per variety. For example, in 2004 the variety Harrington was found to have a bushel weight of 55.43 lb/bus for 100% germ, while B1602 was 49.50 lb/bus, AC Metcalfe 56.39 lb/bus and CDC Bold 50.78 lb/bus respectively. If anything influenced the stand of barley post-plant, (either prior to emergence or post-emergence), no further adjustments to plant stands were undertaken under the assumption all seeds had an equal chance for further failure once the seed amounts per plot and rate had been adjusted for germ and seed size prior to plant. The thought being that say for example, if a denser stand of barley created by a higher seeding rate caused unintentionally more soil-borne mortality of barley seedlings resulting in perhaps poorer yields, quality of seed, or both, then so be it as that is what would happen on a farm level.

METHODS AND MATERIALS:

As early as possible each season the trials were planted at both Fort St. John (FSJ) and Dawson Creek (DC) in separately randomized trials. Planting was accomplished with a double-disc drill, especially adapted for research, which allowed for the individual applications of seed (treatments) per plot. Thus, a completely randomized block design (RCBD) could be followed, giving us full use of statistical procedures. Small-plots restrict the effect of variability from a given field that can

[1]O'Donovan, J.T.[a], Clayton, G.W.[b], Harker, K.N.[b], and Turkington, T.K.[b] *Estimating Barley Plant Density and Yield as a Function of Seeding Rate in Alberta Canada*, Diss. Agriculture and Agri-Food Canada, 2004. Beaverlodge[a] and Lacombe[b], Alberta, Canada.

directly affect treatments. Thus, other than the delivery system that was specially designed to deliver individual treatments per plot, the research planter used similar discs, planting parts, and methods as those found on many full-scale farm drills.

Each plot was 6 rows wide at 20 cm (8”) each, by 7 metres long, giving a total plot area of 8.4 m^2 at planting. Plots were trimmed back in season to ensure equal plot length, avoid treatment overlaps, and to provide a pathway between replicates for viewing and assessment gathering.

Precision electronic scales were used to weigh and prepare individual plot treatments, work with pre-harvest head moisture calculations, and post-harvest to record yields and other grain parameters.

Weeds were controlled each year via normal herbicide choices used in the B.C. Peace region for fields destined to make malt barley grade.

A small-plot research combine was used to harvest each plot separately each autumn as soon as conditions would allow, and harvested samples were further air-dried in the warehouse in order to equalize and stabilize grain moisture content using only ambient air temperatures (no heat was applied).

Maturity data was undertaken by collecting and drying down 25 fresh heads of barley from each plot within three out of the four replicates, once the grain within the heads had reached an average of approximately 25% moisture in the field. Sampling of heads from barley of non-treatment plots prior to and after this head harvest was utilized in order to arrive at an accurate “percent dry-down” per day used to derive the number of days to maturity for each plot. (20% head moisture was considered mature). Using this total head dry-down method has proven to be a reliable quantitative method of deriving an accurate maturity assessment and is not influenced by conditions at harvest as grain moisture methods can be. The Regional and Co-operative barley tests in Alberta have adopted this method.

RESULTS:

TABLE 1.1

	Yield - Bu/Ac								
	2004		2003		2002				
Seeding Rate	DC	FSJ	DC	FSJ	DC	FSJ	Overall Avg	DC Avg	FSJ Avg
1.5 bus/acre	102.57	90.18	111.414	105.48	74.48	87.46	95.264	96.15467	94.37333
1.75 bus/acre	101.41	86.43	114.088	107.06	77.3	88.25	95.7563333	97.59933	93.91333
2 bus/acre	100.24	89.62	114.001	104.21	77.49	87.88	95.5735	97.24367	93.90333
2.25 bus/acre	100.41	92.54	114.706	107.05	78.36	85.78	96.4743333	97.82533	95.12333
2.5 bus/acre	98.56	92.23	117.769	102.29	81.74	86.1	96.4481667	99.35633	93.54
2.75 bus/acre	93.72	89.33	117.203	106.58	78.93	88.97	95.7888333	96.61767	94.96
CV value =	5.76%	9.76%	5.39%	7.23%	5.71%	5.49%			
Factor A prob.=	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001			
Factor B prob.=	0.0009	0.4096	0.0573	0.4318	0.0013	0.3799			
Factor A x B prob. =	0.5707	0.5345	0.7346	0.9585	0.4014	0.4362			

	Maturity - "Days to 20% Moisture"								
	2004		2003		2002				
Seeding Rate	DC	FSJ	DC	FSJ	DC	FSJ	Overall Avg	DC Avg	FSJ Avg
1.5 bus/acre	101.702	106.0427	96.3	98.3			100.586168	99.001	102.1713
1.75 bus/acre	100.196	107.6171	96.1	97.8			100.428282	98.148	102.7086
2 bus/acre	98.451	106.1292	94.8	97.1			99.1200433	96.6255	101.6146
2.25 bus/acre	98.134	106.1416	94.9	98.1			99.3188948	96.517	102.1208
2.5 bus/acre	99.472	107.7795	95	96.8			99.7628643	97.236	102.2897
2.75 bus/acre	99.443	107.1678	93.3	97.1			99.252706	96.3715	102.1339
CV value =	2.86%	2.24%	1.60%	1.45%					
Factor A prob.=	0.1457	0.0001	0.0001	0.0001					
Factor B prob.=	0.0481	0.2622	0.0002	0.0464					
Factor A x B prob. =	0.7486	0.138	0.0412*	0.1277					

TABLE 1.1 *continued…*

	Percent Kernel Protein								
	2004		2003		2002				
Seeding Rate	DC	FSJ	DC	FSJ	DC	FSJ	Overall Avg	DC Avg	FSJ Avg
1.5 bus/acre	13.28	11.09	13.89	11.56	14.52	11.35	12.615	13.89667	11.33333
1.75 bus/acre	13.24	11.02	13.8	11.28	14.35	11.22	12.485	13.79667	11.17333
2 bus/acre	13.4	11.05	13.82	10.79	14.35	11.48	12.4816667	13.85667	11.10667
2.25 bus/acre	13.39	11.12	13.76	10.79	14.27	11.23	12.4266667	13.80667	11.04667
2.5 bus/acre	13.45	11.18	13.75	10.96	14.28	11.43	12.5083333	13.82667	11.19
2.75 bus/acre	13.46	11.3	13.75	10.86	14.27	11.3	12.49	13.82667	11.15333
CV value =	1.25%	3.94%	1.17%	4.57%	Pooled**	Pooled**			
Factor A prob.=	0.0001	0.0001	0.0001	0.0001	Pooled**	Pooled**			
Factor B prob.=	0.0009	0.5146	0.2319	0.0017	Pooled**	Pooled**			
Factor A x B prob. =	0.5313	0.976	0.6504	0.1111	Pooled**	Pooled**			

	TKW								
	2004		2003		2002				
Seeding Rate	DC	FSJ	DC	FSJ	DC	FSJ	Overall Avg	DC Avg	FSJ Avg
1.5 bus/acre	47.078	49.116	44.382	42.817	47.06	47.02	46.2455	46.17333	46.31767
1.75 bus/acre	47.166	48.713	43.625	43.3	47.15	47.29	46.2073333	45.98033	46.43433
2 bus/acre	46.128	48.644	43.915	42.14	46.45	46.94	45.7028333	45.49767	45.908
2.25 bus/acre	46.506	48.186	43.583	41.938	46.27	46.2	45.4471667	45.453	45.44133
2.5 bus/acre	46.053	46.689	43.65	42.167	46.24	45.42	45.0365	45.31433	44.75867
2.75 bus/acre	45.431	47.581	42.937	40.917	45.99	45.47	44.721	44.786	44.656
CV value =	3.87%	3.60%	3.12%	5.06%	2.35%	2.35%			
Factor A prob.=	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001			
Factor B prob.=	0.0669	0.0022	0.1033	0.0523	0.0168	0.0001			
Factor A x B prob. =	0.9464	0.8533	0.2925	0.1146	0.8302	0.1994			

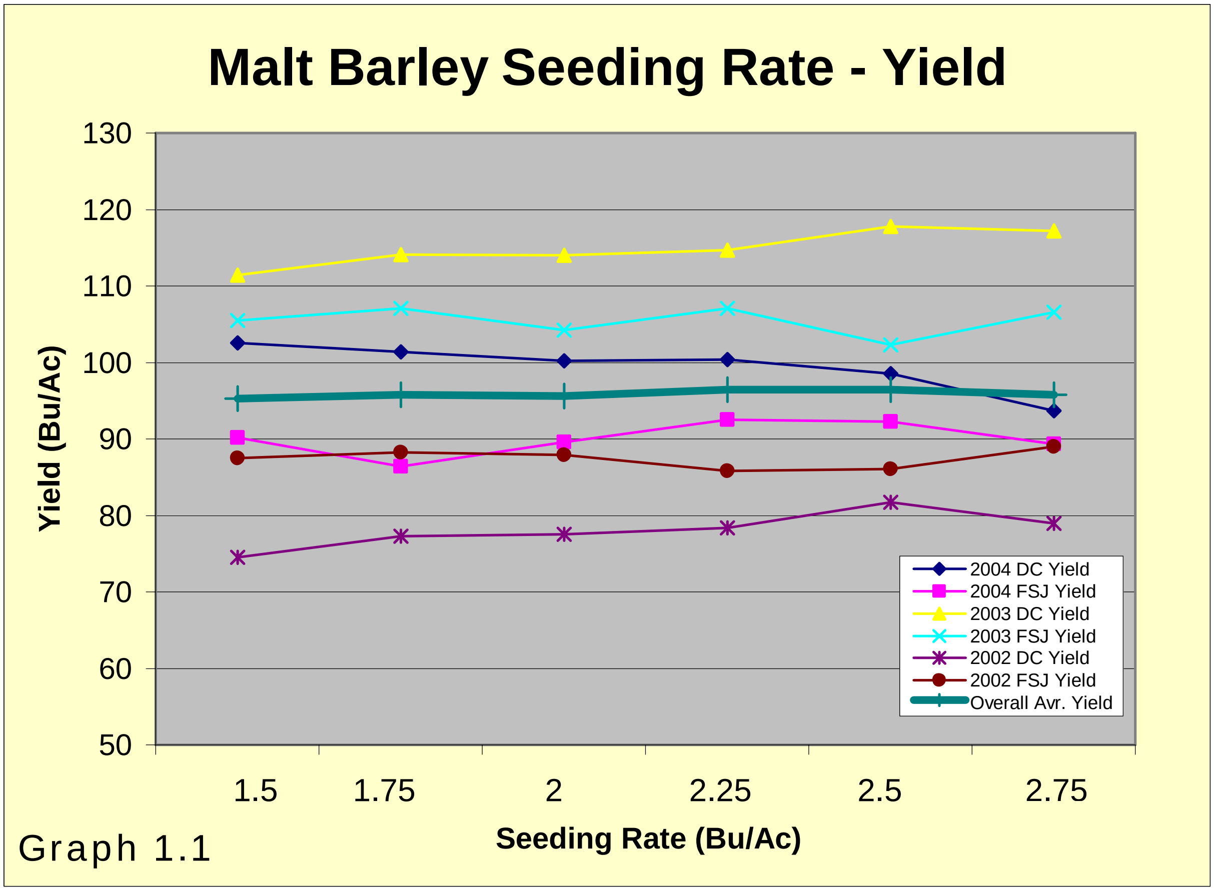
TABLE 1.1 *continued…*

	% Plumps								
	2004		2003		2002				
Seeding Rate	**DC**	**FSJ**	**DC**	**FSJ**	**DC**	**FSJ**	**Overall Avg**	**DC Avg**	**FSJ Avg**
1.5 bus/acre	92.86295	91.48113					92.172039		
1.75 bus/acre	91.96866	91.68066					91.824657		
2 bus/acre	93.24052	91.34563					92.2930755		
2.25 bus/acre	93.05476	90.63512					91.8449405		
2.5 bus/acre	92.86447	89.8204					91.3424375		
2.75 bus/acre	93.10961	90.79886					91.9542355		
CV value =	2.36%	2.46%							
Factor A prob.=	0.0001	0.0001							
Factor B prob.=	0.6312	0.1980							
Factor A x B prob. =	0.6961	0.6222							

Note that results displayed in *Table 1.1* above do not display the values found for *Factor A* (variety) alone, as we are not trying to investigate which variety is higher yielding than the other, or has more kernel protein, and so on, as this is not a "*variety performance type*" trial. The main reason for four varieties was to see if there would be an *interaction* between "*variety*" and "*seeding rate*", and since the "*interactions*" do not appear to exist, (shown by the lack of significance via the probabilities displayed above for "A x B"), and then we need only concentrate on results from *Factor B* (seeding rate). The fact there is no significance to the interaction is a good thing, as that means all barley varieties tested responded the same to "seeding rate". There is one minor exception, and that being the interaction for Dawson Creek regarding *variety x maturity* in 2003 but is of minor significance*. Also note that *% Plumps* was a parameter that was not started until 2004, thus data is inconclusive at this point but two more years of such data should be available by the end of year five.

*Pooled*** means samples from each treatment from each of three separate replicates were pooled (mixed) together to form one composite sample per treatment, before being analyzed. Later wisdom thought it best to always analyze data from individual plots in order to allow full statistical analysis for any parameter undertaken in this study.

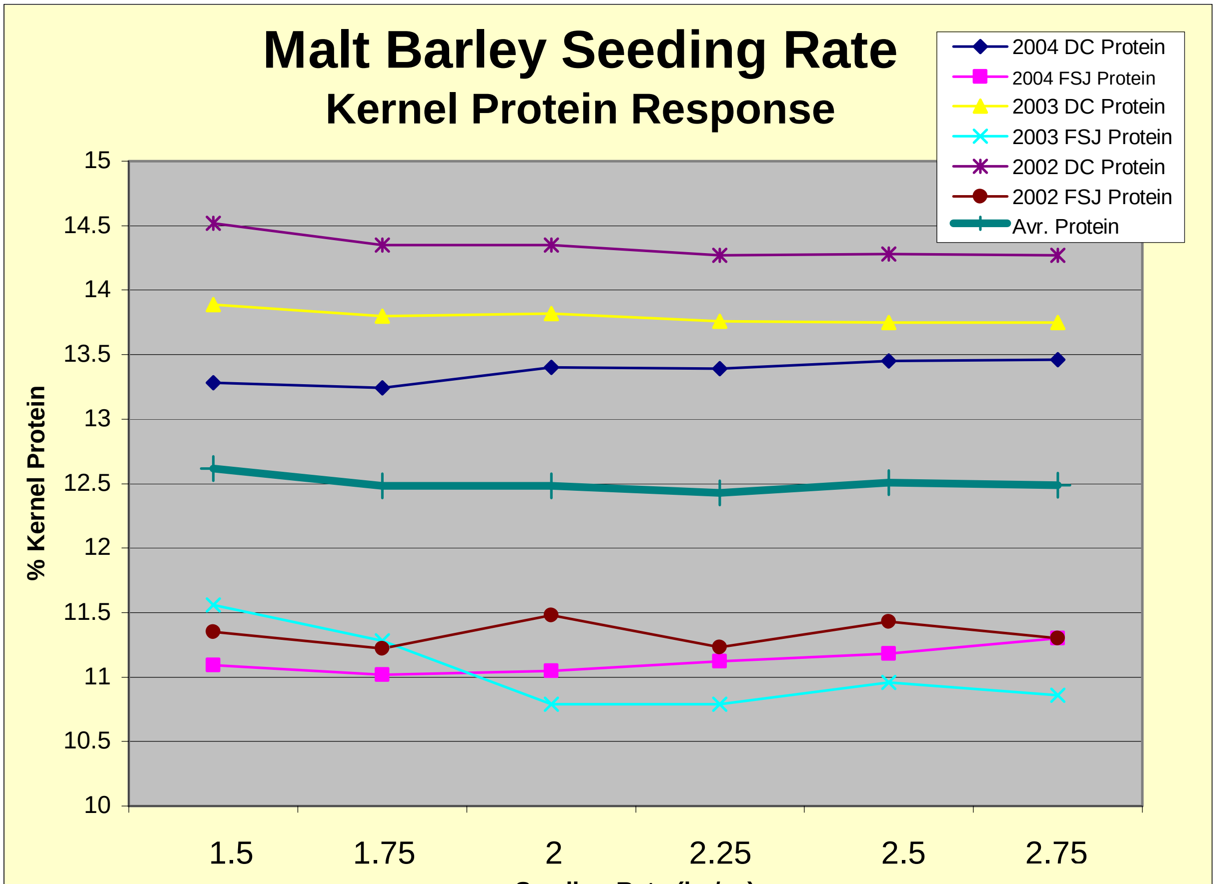
Yield Response to Seeding Rate:



Graph 1.1 clearly shows that although the overall averaged means displayed above show an ever so slight increase in yield by increasing seeding rate to a peak response at 2.5 bushels per acre seeding rate, (see the green line in above graph), there is no significant response in yield to seeding rate. This appears to be the case no matter if one compares the North Peace site (Fort St. John (FSJ)) to the South Peace site (Dawson Creek (DC)). FSJ traditionally over the three years of this study has been a normal site with respect to available soil moisture, while DC has been a dry site with a deficit in available soil moisture. Clearly, as data suggests up to now, there is no advantage to increasing malt barley seeding rates in order to increase yield.

Kernel Protein Response to Seeding Rate:

Graph 1.2 displays kernel protein response to increased seeding rates. The FSJ site (the three lower response lines) clearly shows more suitable (lower) protein level at any of the six seeding rates, than that of the protein results from DC (the upper three response lines). It is believed that this is simply a matter of environmental conditions, which were different between the two sites. Normally, it is generally believed that as yield increases protein content drops, but this does not prove to be the case here as DC has the highest yields and protein content as compared to FSJ. Growing under less than ideal soil moisture content it is unclear as to why this is for DC. In the end however, as with yield response, there appears to be no real (significant) advantage gained for kernel protein by manipulating (increasing) seeding rate at plant.

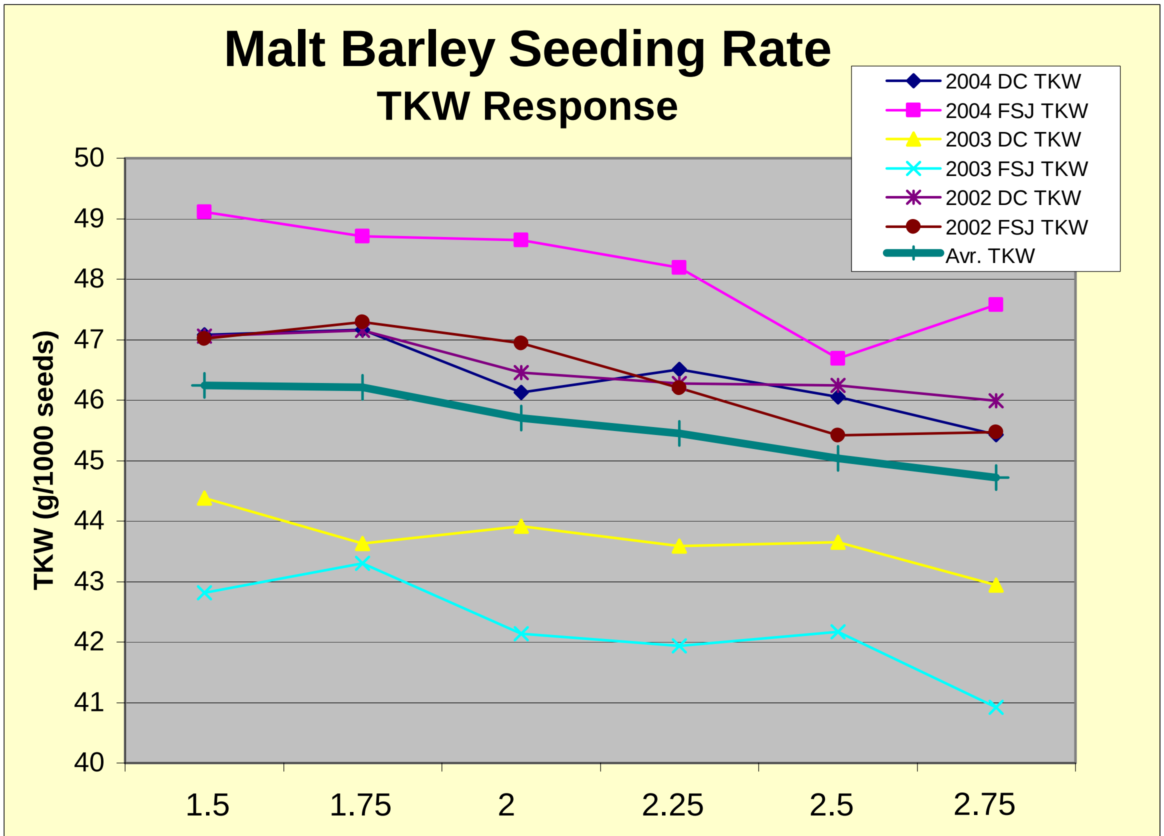


Graph 1.2

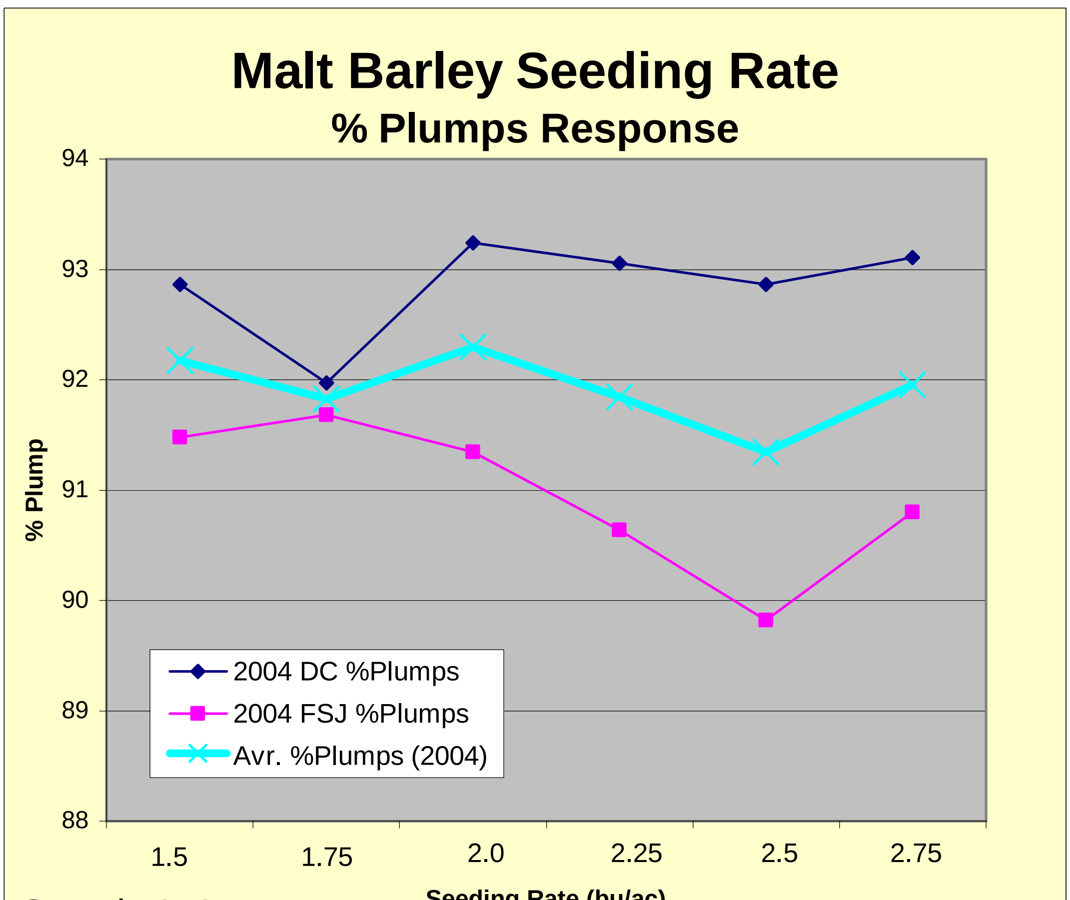
Thousand Kernel Weight (TKW) & %Plumps Response to Seeding Rate:

Seed weight, as described by TKW, does prove to be somewhat affected by increased seeding rate, and as illustrated in *Graph 1.3*, TKW decreases slightly as seeding rate goes up. It is not a significant loss in seed weight as the overall response line (green), drops only 0.5 grams (approximately) as seeding rate increases from 1.5 bushels per acre to 2.25 bushels per acre. It again appears that overall there is no real advantage, (or in this case disadvantage), to TKW as it relates to increasing the malt barley seeding rates. There is perhaps some concern as to a possible detrimental affect against TKW by increased seeding rates under certain environmental conditions as noted in FSJ in 2004 (the fuchsia line at the top of *Graph 1.3*), where 2.4 grams are lost between 1.5 bushels per acre and 2.5 bushels per acre seeding rate. Malting barley grade demands plump kernels, and although TKW is not necessarily the most definitive way of describing such a characteristic, a drop of 2.5 grams is at least a point of interest to watch over the next two years.

Graph 1.4 deals specifically with the percentage of plump kernels, as measured by the percentage of seeds that do not pass through a 6/64th by 3/4th inch slotted screen opening, a standard screen used in the malting trade for this value, as making the malting grade means you need a high percentage of plump seed. Data is very limited as this parameter was only started in 2004, as previous to 2004 there was no evidence (via TKW) of any negative affect on seed size or weight. In 2004 at FSJ however, along with the drop in TKW at the 2.5 bus/ac seeding rate, a drop in %plumps is also witnessed. These two parameters (TKW and %plumps) will have to be watched in 2005 and 2006.



Graph 1.3

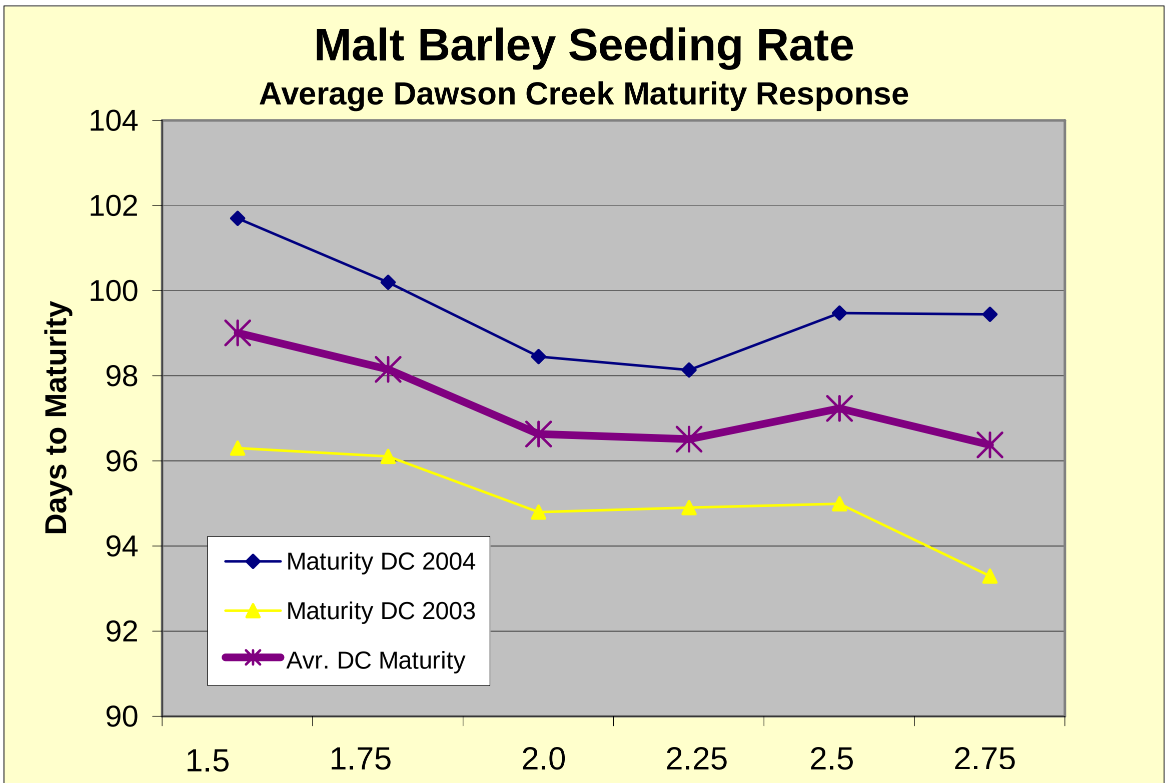


Graph 1.4

Maturity Response to Seeding Rate:

Maturity refers to the number of days from plant that it takes for the barley grain in the heads to reach moisture content below 20%. The barley at this point can be referred to as being physiologically mature, a point that the environment can no longer prevent the completion of seed dry-down. Collection of maturity data started in 2003 when the issue came to light via suggestions made by Dr. John O'Donovan from his similar work in Alberta, (see footnote bottom of page 2). Results show us apparently two completely different responses of maturity to seeding rate depending on location (FSJ in the north verses DC in the south Peace). The difference appears to be more of a function of available soil moisture (and therefore likely fertility issues too) however, rather than location itself. Therefore the two sites (FSJ and DC) will be looked at separately. *Graph 1.5* and *Graph 1.6* displays maturity responses from FSJ and DC respectively.

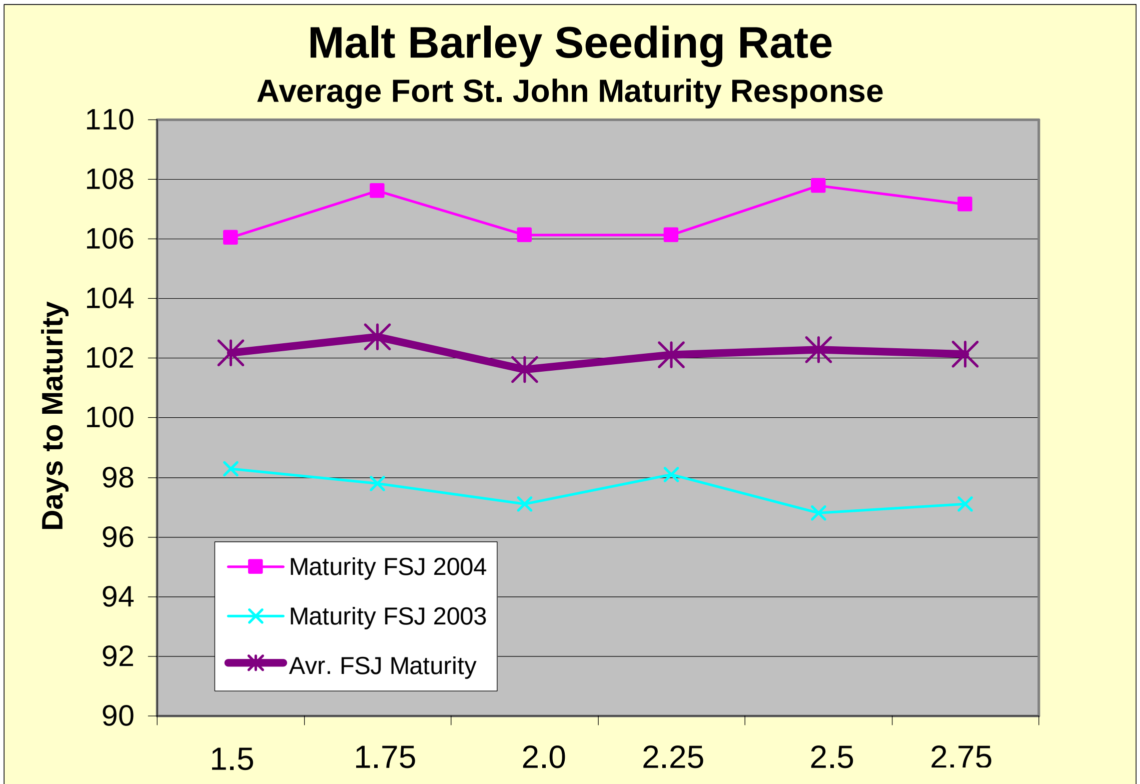
First, lets consider the data from Dawson Creek, B.C., a site that during both 2003 and 2004 was under stress as a result of a "surface" drought, for a good part of the barley-growing season.



Graph 1.5

Graph 1.5 above shows a general decrease in maturity as seeding rate increases, with the best advantage, (shortest number of days to reach maturity), looking to be around the 2-2.25 bushels per acre seeding rate. At this seeding rate level it seems (as based only on 2004 data at this point) we would not be heavily penalized in *% plumps* or in *TKW*, (as based on TKW data from 2002-2004). There is a drop in maturity at this seeding rate level of about two days within the overall average curve (purple) for DC between the 1.5 and 2.25 bushels per acre seeding rate. In 2004 however, (the dark blue curve), there was a drop in maturity of about four days involving the same seeding rates. Four days might have been the difference in 2004 between getting the crop off before the first early snowfall, as was experienced at the site in 2004, and having it flattened from the snow and thus downgraded in quality due to seed sprouting and colour issues not to mention possible yield losses.

Graph 1.6 below represents how maturity responded at a site where the availability of soil moisture was not an issue, thus likely fertility or the ability of the barley to utilize the fertility present, was working normally. It appears under good environmental conditions (at least as described by soil moisture and fertility availability), maturity responds to seeding rate differently, or in this case, it does not respond at all. A fairly flat-lined response curve (purple for the overall averaged FSJ response curve), results.



Graph 1.6

CONCLUSIONS:

Although this data set represents only three years worth of results from a five-year project, some general conclusions are beginning to develop. Admittedly they could change by the end of year five, but the results as disclosed here, seem to be developing fairly strong trends, and so it seems safe to draw certain conclusions at this point in time.

First, there appears to be no advantage to yield or percent kernel protein to increased seeding rates, whether growing under low levels of available soil moisture (drought) or normal soil conditions.

Second, there is no significant disadvantage to TKW and % plumps, to increasing seeding rates up to 2.25 bushels per acre. There is some question as to possible disadvantages in both TKW and % plumps counts once seeding rates exceed 2.25 bushels per acre, but this concern can only be resolved by further investigations in 2005 and 2006.

Third, there seems to be no benefit or penalty to maturity (days to mature) at higher seeding rates when grown under good to excellent available soil moisture (and therefore possibly higher fertility). But on the flip side, maturity appears to respond positively (maturity is reduced in length) to higher seeding rates of up to 2.25 and 2.5 bushels per acre, while growing under "dryer" conditions (less available soil moisture and thus likely lower available soil fertility). Under these dryer soil moisture conditions, maturity decreasing on an average of 2 days but could decrease by as much as 4 days.

Bottom line (up to now) is thus. Yield or other key important malt characteristics are not adversely affected by increasing the seeding rate to 2.25-2.5 bushels per acre (but especially at the 2.25 bus/ac level due to possible adverse seed size and weight issues at 2.5 bus/ac), yet there may be good reason to increase seeding rates to 2.25-2.5 bushels per acre, in order to decrease the maturity period, a very important issue when dealing with such a short growing season as that of the Peace River region. One does not know at planting time whether the season will be a dry one or a wet to normal one regarding available soil moisture, so increasing seeding rates to 2.25-2.5 bushels per acre would be comparable to another form of cheap crop insurance, much like seed treatment is – you never know when you need it but are glad you used it if conditions arrive that promote its benefits.

In closing, it should be remembered that there are other agronomic advantages to increased seeding rates that this project did not look into, such as better weed control, specifically a possible reduction in wild oat counts within the barley crop. Therefore, any additional agronomic advantage, such as a possible decrease in the maturity period which can ultimately help to keep a barley crop within the malt barley characteristics needed to grade as malt, is a bonus, especially in short growing season areas like the Peace River region.

It should be interesting to see what the years 2005 and 2006 do to the data and thus the final conclusions post-harvest 2006.

TABLE 3 – 2004 B.C. Peace River Weather Summary

2004 Summary of Monthly Averages for Temperature and Precipitation Data

** Supplied by BC Crop Insurance

	Ambient Air Temperatures **			
		Avg. Mean	Avg. Mean	Precipitation
	Avg. Mean	Temp (C)	Temp (C)	At actual site
Dawson Creek, B.C.	Temp (C)	Minimum	Maximum	(MM) **
March, 2004	-3.34	-9.98	3.19	9
April, 2004	4.89	-2.71	12.03	8
May, 2004	8.56	0.33	16.07	12
June, 2004	15.67	7.27	23.64	19
July, 2004	17.13	10.21	24.42	77
August, 2004	14.28	7.20	21.89	75
September, 2004	8.00	3.04	13.46	74
October, 2004	2.23	-3.29	8.01	10
Total Season Precipitation =				284

	Ambient Air Temperatures **			
		Avg. Mean	Avg. Mean	Precipitation
	Avg. Mean	Temp (C)	Temp (C)	At actual site
Fort St. John, B.C.	Temp (C)	Minimum	Maximum	(MM) **
March, 2004	-3.57	-9.74	3.55	18
April, 2004	4.74	-1.82	11.53	18
May, 2004	8.07	0.92	15.16	19
June, 2004	15.22	7.94	22.27	48
July, 2004	16.76	10.05	23.71	98
August, 2004	13.52	7.03	20.53	72
September, 2004	7.50	3.54	12.34	102
October, 2004	1.55	-3.30	6.32	8
Total Season Precipitation =				383