MALT BARLEY NITROGEN AND PROPICONAZOLE APPLICATION: AN AGRONOMIC STUDY

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ABSTRACT

Producing malt grade barley can significantly increase farm profits and is thus a key crop option for local Peace region producers. Malt barley is grown across Western Canada; therefore many of the guidelines to successfully growing malt barley have been established. However, the Peace River region has unique attributes, which may require a modification of such techniques. It is the goal of this study to look at two aspects that may influence the optimal conditions for producing malt grade barley: application of nitrogen and use of propiconazole as a foliar disease protectant. As it worked out, the drought years were not used due to poor CV or loss of data, thus data reflects adequate moisture conditions. The results indicate that there is no benefit to applying propiconazole to a variety like AC Metcalfe, a variety with improved disease resistance, and that the yield response increases steadily with an increased rate of nitrogen applied. The seed size as tested through HLW, TKW and percent plumps is non-responsive to either nitrogen application rate above 40 lb actual N per acre, or foliar fungicide protection, and the protein content saw only a slight increase to nitrogen application rate above the initial rate of 40 lb actual N per acre.

INTRODUCTION

Malting barley demands a premium price over feed barley, increasing its appeal as a diversification crop (Johnston et al., 2007). The quality requirements for malting barley are reasonably strict: these requirements are directly related to the processing efficiency and product quality. A few of these requirements include: an acceptable variety, 95 percent germination or higher, 11-12.5 percent protein, 13.5 percent maximum moisture content, plump kernel of uniform size and full maturity (bmbri, 2005). The producer may control many of these characteristics while others are influenced by weather conditions experienced during the growing and harvest seasons.

In the spring of 2002, the BC Grain Producers Association initiated agronomic trials to determine the best method of stabilizing malt barely characteristics. Seeding rate was looked at separately while fertilizer and disease where studied together here. The response of yield, protein, and seed size through plumps, thousand-kernel weight and hectolitre weights were observed over the five-year study. Kernel plumpness and protein content are generally the dominant quality factors associated with malt barley production, and the main component of a fertilizer program necessary for production of high quality malt barely is nitrogen (Jackson, 2000).

With low available nitrogen in the soil malt barley responds well to applied fertilizer, showing increases in both yield and protein content. However, too much nitrogen can increase protein beyond levels set by the maltsters. This increase in protein may lengthen steeping times, make germination more erratic and create undesirable qualities in the malt (Johnston et al., 2007). .

Precipitation and nitrogen supply, in part, determine the protein content and yield, providing other factors are not limiting. Higher levels of precipitation will cause a lower protein content, whereas drier conditions means a higher protein content for the same amount of nitrogen available. Moisture stress during grain filling can result in a higher protein level and reduced plumpness; therefore the timing of precipitation is also vital. The protein content and yield will increase with an increased rate of nitrogen, however the protein content will increase at a slower rate. As an example, when the Nitrogen application doubles the yield, the protein content may only see a one to two percent increase (McLelland et al., 1999)

The second part of this study involved the application of propiconazole, a locally systemic foliar fungicide. A well established and common fact is that leaf diseases can rob plants of their ability to supply good seed fill, seed set while shorten the productive life of a plant thus yield and seed quality can be adversely affected. Thus this study was set up to study the affect of applying a foliar fungicide at the correct timing for best disease protection on barley, a period of time for application of propiconazole between stem elongation to before the barley head is half emerged. The theory being that the greater the yield potential the greater the level of protection one could expect to receive from the application of a foliar fungicide to barley, assuming yield would increase as nitrogen application increased.

A single popular line of barley was chosen for the study, AC Metcalfe, as it was widely being grown in the Peace River region and was rapidly replacing its predecessor Harrington at the time the study was initiated. AC Metcalfe is a major improvement with regard to genetic ability to resist attack from one of the most common leaf diseases of barley in the Peace River region, that of Scald, Rhynchosporium secalis (Oud.) Davis. As such it was realized from the beginning of the study that the level of protection propiconazole or any other foliar fungicide product could offer, would be limited as disease levels would be limited via the improved genetics offered by AC Metcalfe over its predecessor Harrington. If seed quality could be improved by disease protection, even if perhaps significant yield increases could not, it was deemed still worthy to investigate. This five-year study is part of the larger goal, to find malting barley, which meets set standards while excelling in the unique attributes of the Peace River region. Information from the Western co-op trials, will determine those new varieties best suited for growth in the Peace River region, while the two agronomic studies will determine the optimal conditions for the producers to utilize. This study will look specifically at fertilizer application rates and disease control.

MATERIALS AND METHODS

Two farm sites are used to collect data: the first is located in the South Peace at Dawson Creek, the other is in the North Peace at Fort St. John. The sites are kept as identical as possible and are treated equally throughout the season. Plots are planted, maintained, analyzed and harvested according to proper research protocol. Application of the foliar fungicide propiconazole was undertaken according to product label for barley.

Each plot has a total area of 8.4 meters squared at planting, six rows wide each at 20 cm spacing (eight inches) by seven metres long, which are trimmed back in season to ensure plot length, avoid treatment overlaps while providing a pathway between replicates for viewing and assessments. The range of nitrogen application levels chosen and the fertility levels applied for phosphorous and potash, were maintained to represent levels expected for malt barley production in the Peace Region and guided by spring soil sampling results taken each spring prior to planting.

The barley chosen for study was the variety AC Metcalfe; a variety that was widely being grown in the Peace River region and was rapidly replacing its predecessor Harrington at the time the study was initiated. Weeds were controlled with common herbicides used for malt grade barley in the Peace River area.

Fertilizer is deep-banded at planting one inch below and one inch over from the seed placement. The rates are determined through soil testing in the spring, using the most nitrogen hungry section of the sites. The soil nitrogen available is then used to determine the amount of fertilizer required: so that to the best of knowledge, the listed amount of fertilizer is the actual amount available to the plant, through soil and fertilizer. The rates of fertilizer application are: 40, 50, 60, 70, 80 and 90 pounds actual nitrogen per acre, which includes compensation for available soil nitrogen as per spring soil test per site prior to planting. The different rates of nitrogen, blended with a common phosphorous and potash requirement, were applied to each plot individually via the planter that was designed for individual fertilizer release per plot.

Foliar fungicide application occurred when the first signs of significant disease was detected, usually close to the growth stage represented by half exposure of barley heads from the boot of the plants. Application was made via a CO_2 pressurized backpack sprayer and hand-held 1.5 m boom angled in such a way as to allow operator to walk between treatment plots while boom remained positioned correctly over plot being treated. No less than 40 PSI was used for operating pressure and high solution volumes were chosen at around twenty US gallons per acre or better output, applied from flat-fan small droplet nozzle tips. Small droplet tips, high operating pressure, and high solution volumes assured good coverage and good crop penetration. Other nozzle tips were not considered as the majority of commercial pesticide operators in the area, custom and by producers alike, only use flat-fan tips for most pesticide applications. It was decided to mimic their choice of nozzles. Better coverage may have been possible with hollow cone nozzle designs, but experience and observations showed coverage was adequate as applied under these conditions.

RESULTS & DISCUSSION

The following data was lost and is thus not included in the following figures and tables:

2003 DC lost due to background soil nitrogen levels too high and incomplete data.

2004 DC and FSJ lost from early heavy snowfall damage prior to harvest. Harvest was still undertaken, but results were suspect due to the severity of crop lodging and seed shatter from the heavy and early snowfall.

2006 DC lost from a severe drought experienced at the site; data rejected by high Coefficient of Variance value for yield.

TKW and HLW data from 2002 DC was not undertaken as the decision to collect such data came after the samples had been discarded from 2002. Missing data for percent plumps and percent protein is missing for similar reasons. DC equals Dawson Creek, BC and FSJ equals Fort St. John, BC

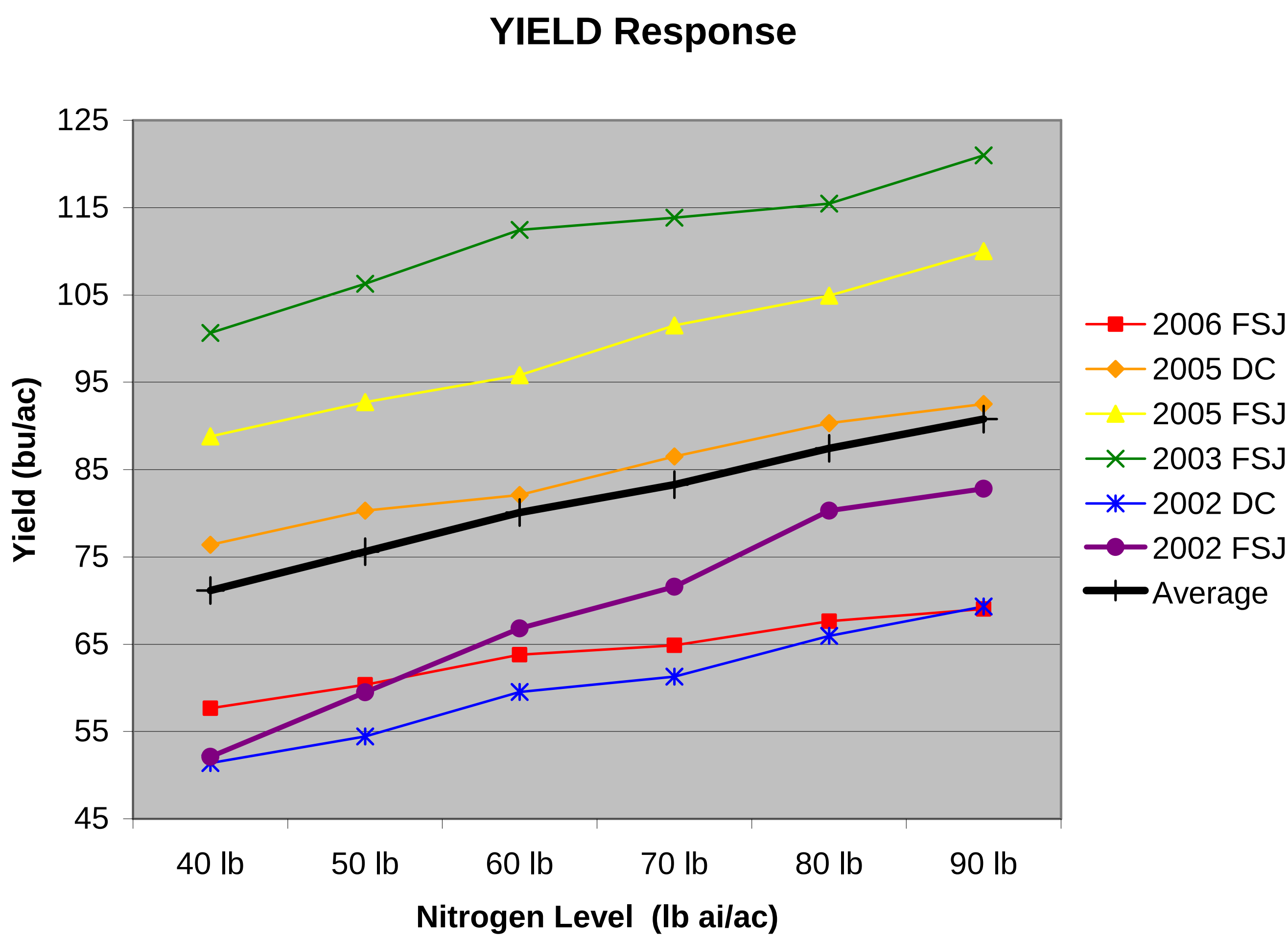

Figure 1. Yield response of malt barley to nitrogen in Dawson Creek and Fort St. John

This shows textbook trends, with the yield increasing incrementally with each incremental increase in application of nitrogen. This is the desired effect, as long as the other parameters do not show undesirable trends. As the data from drought years, 2002 and 2006 from Dawson Creek, were rejected from use, this dataset could be said to represent yield response from ideal moisture conditions, and may have been less responsive had drier year's data been acceptable for incorporation into the dataset above.

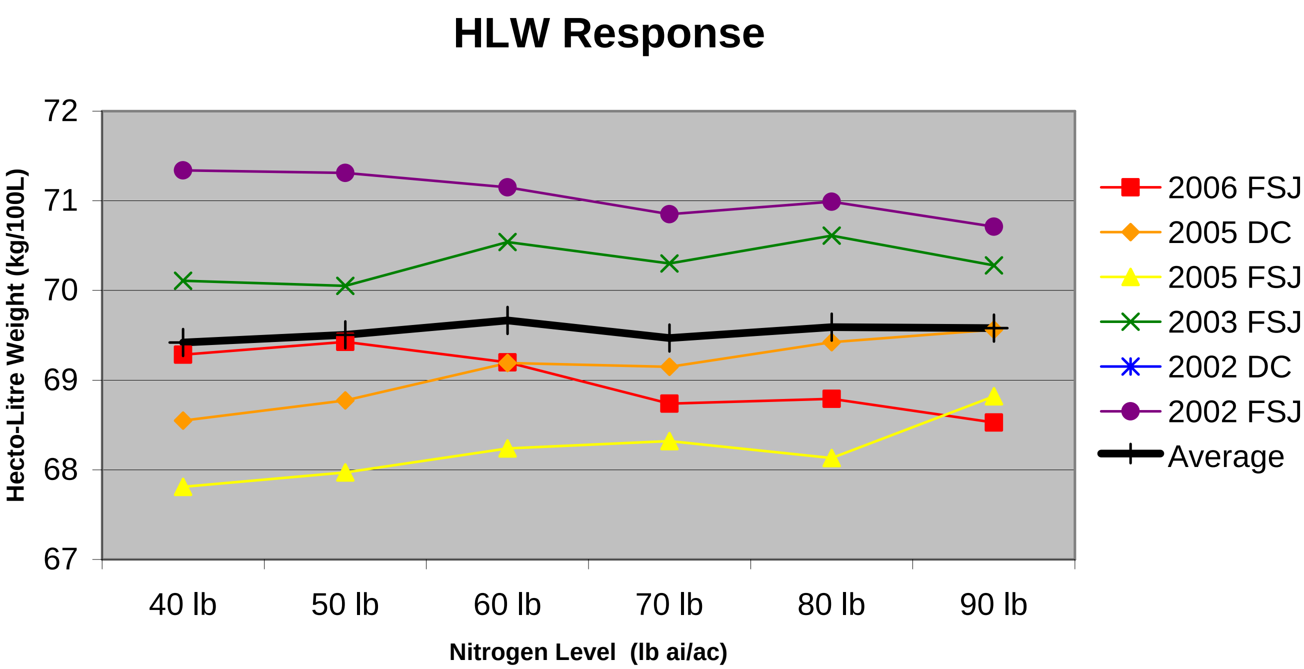

Figure 2. Hectolitre weight response of malt barley to nitrogen in Dawson Creek and Fort St. John

The average hectolitre weight remains close to the 69.5 mark, leaving a relatively flat line. According to this chart, the addition of nitrogen above 40 lb actual N/acre is not critical. There is a peak at 60 pounds, however this is so slight that it is hardly worth mentioning and is statistically insignificant.

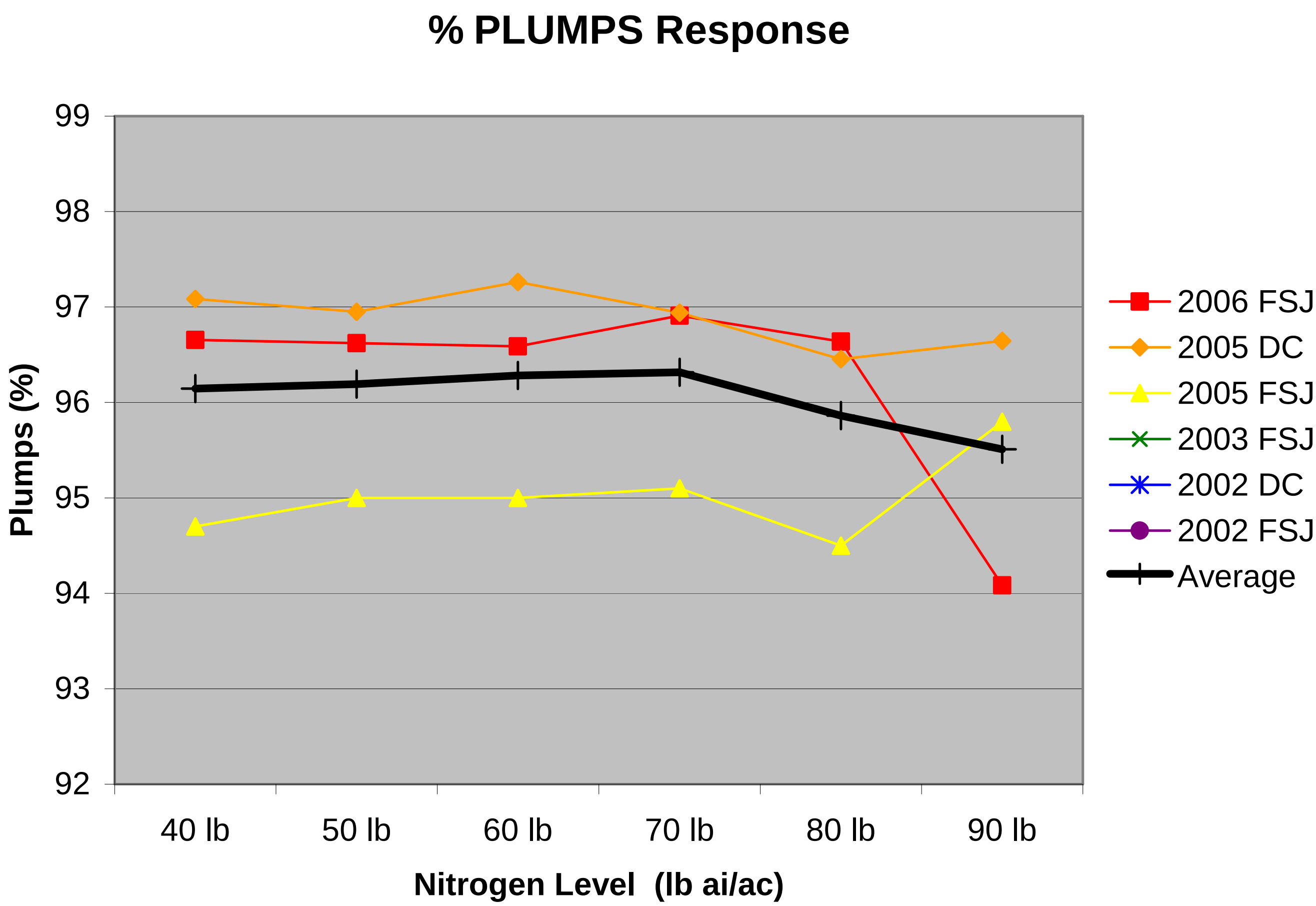

Figure 3. Percent plumps response of malt barley to nitrogen in Dawson Creek and Fort St. John

The trend seen here is relatively a flat line until 70 pounds, where there is a slight peak and then a drop. This is undesirable, as a plump uniform seed is a trait required to meet malt standards. Therefore it would seem there is no benefit to increasing nitrogen beyond 70 lb actual N/acre for this reason and according to % plump response data.

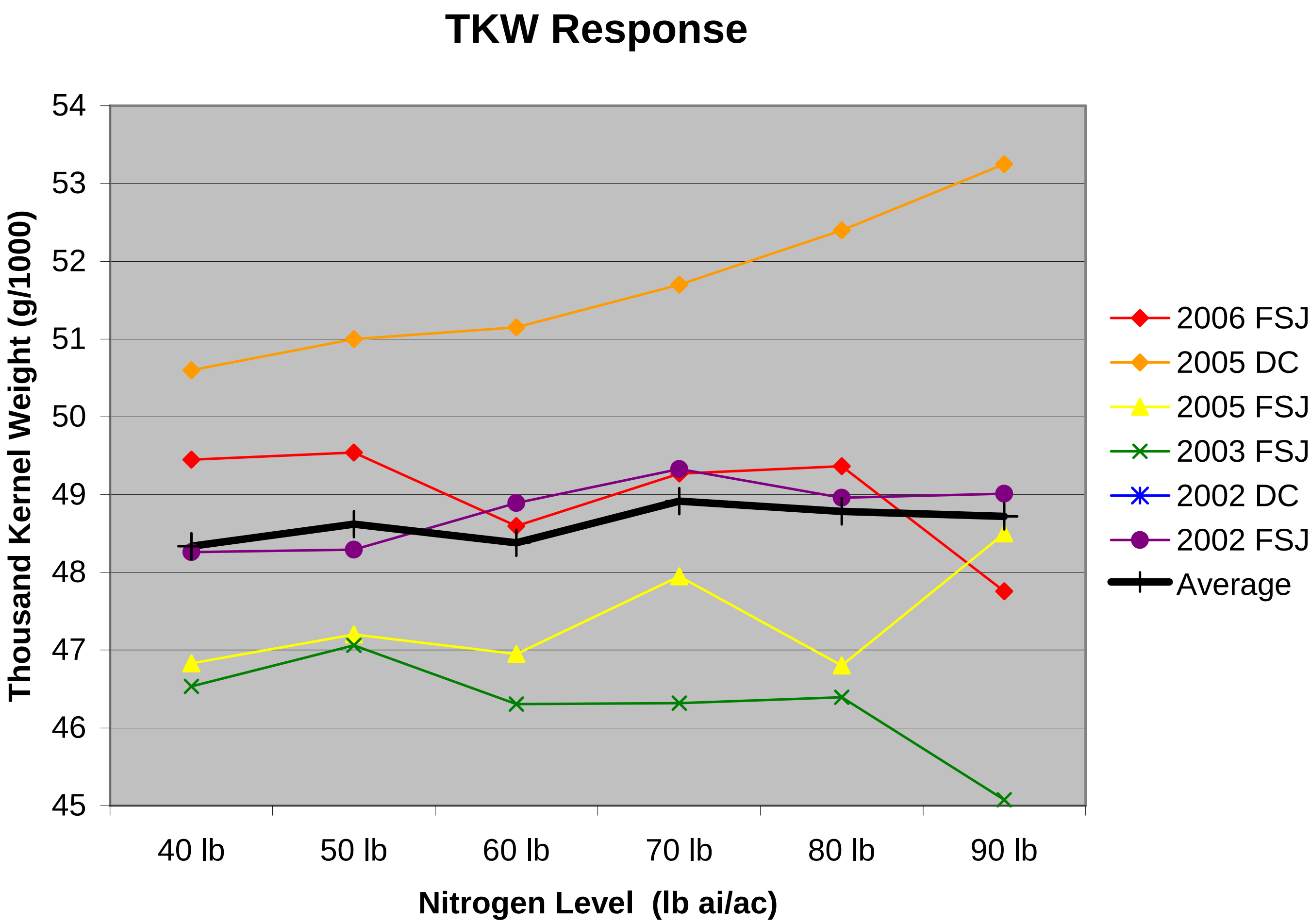

Figure 4. Thousand-kernel weights response of malt barley to nitrogen in Dawson Creek and Fort St. John

The average indicated that there is a slight increase in the thousand-kernel weights with an increased application of nitrogen. This increase appears to peak at 70 pounds per acre, however, this increase is not significant and results for thousand kernel weight represents for the most part a flat-line response to increased nitrogen beyond 40 lb actual nitrogen acre. This is surprising and unexpected.

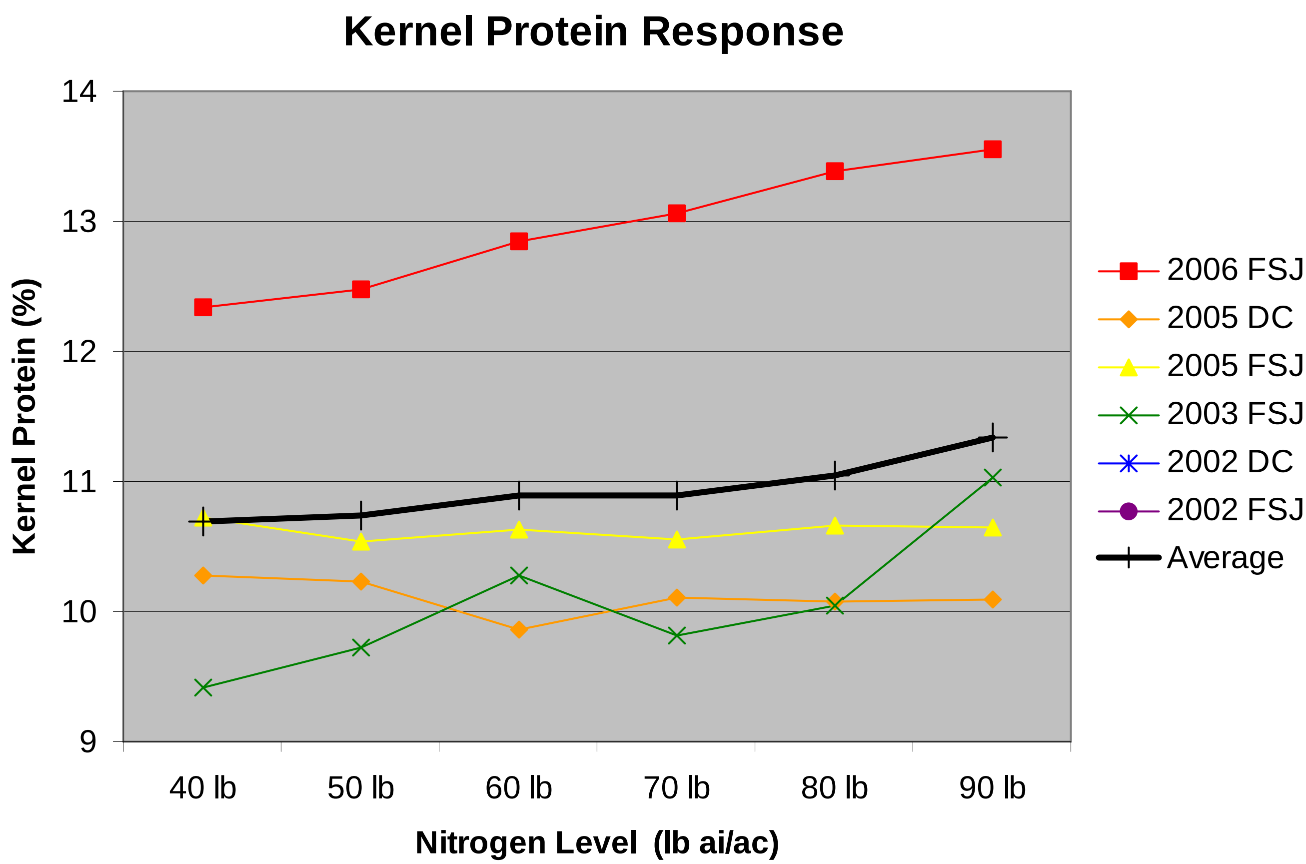

Figure 5. Kernel protein response of malt barley to nitrogen in Dawson Creek and Fort St. John

These results include those years with good growing conditions. Those years, which had experienced a drought and thus had high protein levels, also had very poor Coefficient of Variation statistical values or incomplete datasets and therefore that data was not used. Had this data been used, a much larger increase would have been seen in the kernel protein levels as nitrogen rate increased.

Therefore is should be noted that nitrogen application becomes a risk management, as it is unknown what type of growing season will occur, if a drought is experienced, chances are that the protein content will be too high for malt grade at any level of nitrogen beyond 60 lb actual N per acre as indicated by the response curve above for Fort St. John in 2006. Fort St. John in 2006 also experienced drought conditions, just not as severe as that experienced in Dawson Creek of the same year. However, data above show that in a good year with sufficient moisture, the profits would likely be seen for additional nitrogen beyond the 60 lb actual N per acre rate.

Table 1. Malt barley yield response to applied nitrogen

	2006 - FSJ		2005 - DC		2005 - FSJ		2003 - FSJ		2002 - DC		2002 - FSJ		Average	Average
	YIELD kg/ha	YIELD bu/ac	YIELD kg/ha	YIELD bu/ac	YIELD kg/ha	YIELD bu/ac	YIELD kg/ha	YIELD bu/ac	YIELD kg/ha	YIELD bu/ac	YIELD kg/ha	YIELD bu/ac	YIELD bu/ac	YIELD bu/ac
TABLE OF A MEANS														
140 lb ac N/ac	3102.5	57.7	5536.1	76.4	4778.2	88.8	5413.7	100.6	2765.0	51.4	2801.2	52.1	4066.1	71.2
250 lb ac N/ac	3247.4	60.4	5813.3	80.3	4986.3	92.7	5717.9	106.3	2928.9	54.4	3198.6	59.5	4315.4	75.6
360 lb ac N/ac	3433.2	63.8	5942.7	82.1	5152.3	95.8	6049.4	112.4	3203.3	59.5	3592.4	66.8	4562.2	80.1
470 lb ac N/ac	3490.3	64.9	6262.7	86.5	5461.2	101.5	6124.5	113.8	3297.6	61.3	3854.6	71.6	4748.5	83.3
580 lb ac N/ac	3638.7	67.6	6539.2	90.3	5641.6	104.9	6212.2	115.5	3548.1	66.0	4319.3	80.3	4983.2	87.4
690 lb ac N/ac	3714.5	69.0	6699.0	92.5	5918.4	110.0	6508.2	121.0	3728.6	69.3	4452.5	82.8	5170.2	90.8
TABLE OF B MEANS														
1no foliar fungicide	3460.1	64.3	6042.7	83.4	5151.2	95.7	5978.4	111.1	3271.5	60.8	3724.7	69.2	4604.8	80.8
2propiconazole fungicide	3415.4	63.5	6221.6	85.9	5494.8	102.1	6030.3	112.1	3219.0	59.8	3681.5	68.4	4677.1	82.0
CV =	5.27	5.27	5.53	5.53	8.36	8.36	6.30	6.30	6.16	6.16	7.85	7.85		
Probability for A (Nitrogen) =	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		
Probability for B (Fungicide) =	0.2638	0.2638	0.0766	0.0766	0.0115	0.0115	0.6380	0.6380	0.3619	0.3619	0.6102	0.6102		
Prob. for AxB (interaction) =	0.8559	0.8559	0.1476	0.1476	0.5251	0.5251	0.2607	0.2607	0.5798	0.5798	0.9049	0.9049		

The data from these tables were used to complete the figures shown above, note however the focus for these tables is on the probability section. The probability for factor A, is a very low number, which states that it is a highly significant factor and therefore the data is very reliable and responsive to its levels. This unfortunately is not seen in the probability for factor B the use of a foliar fungicide. In fact the numbers are quite high, stating that the barley did not follow any particular trend, suggesting there is a lack of response in factor B to its levels. There was basically no response to applying foliar fungicide to the barley AC Metcalfe for disease protection. The data from 2005 for factor B shows slight significance with Dawson Creek's probability at 0.0766 and the probability in Fort St. John at 0.0115. The year 2005 represents a year with adequate and timely rainfall and thus significant foliar disease pressures, even for more disease resistant cultivars like AC Metcalfe. The probability for the interaction between nitrogen and the fungicide is shown to not be significant for any year and or site, which mean all factor levels in A respond similarly to levels of B, simplifying results.

Table 2. Malt barley thousand-kernel weight and hectolitre weight response to applied nitrogen

	2006 - FSJ		2005 - DC		2005 - FSJ		2003 - FSJ		2002 - DC		2002 - FSJ		Average	Average
	TKW g/1000	HLW kg/100L	TKW g/1001	HLW kg/100L	TKW g/1002	HLW kg/100L	TKW g/1003	HLW kg/100L	TKW g/1004	HLW kg/100L	TKW g/1005	HLW kg/100L	TKW g/1000	HLW kg/100L
TABLE OF A MEANS														
1 40 lb ac N/ac	49.5	69.3	50.6	68.5	46.8	67.8	46.5	70.1			48.3	71.3	48.3	69.4
2 50 lb ac N/ac	49.5	69.4	51.0	68.8	47.2	68.0	47.1	70.1			48.3	71.3	48.6	69.5
3 60 lb ac N/ac	48.6	69.2	51.2	69.2	47.0	68.2	46.3	70.5			48.9	71.2	48.4	69.7
4 70 lb ac N/ac	49.3	68.7	51.7	69.1	48.0	68.3	46.3	70.3			49.3	70.9	48.9	69.5
5 80 lb ac N/ac	49.4	68.8	52.4	69.4	46.8	68.1	46.4	70.6			49.0	71.0	48.8	69.6
6 90 lb ac N/ac	47.8	68.5	53.3	69.6	48.5	68.8	45.1	70.3			49.0	70.7	48.7	69.6
TABLE OF B MEANS														
1 no foliar fungicide	48.9	68.9	51.4	69.1	46.6	68.0	46.3	70.3			49.0	71.0	48.4	69.5
2 propiconazole fungicide	49.1	69.1	52.0	69.1	48.1	68.4	46.3	70.4			48.6	71.1	48.8	69.6
CV =	3.41	0.75	1.88	0.68	1.77	0.65	2.88	0.72			2.62	0.68		
Probability for A (Nitrogen) =	0.2551	0.0073	0.0001	0.0010	0.0008	0.0017	0.1151	0.1994			0.5028	0.0815		
Probability for B (Fungicide) =	0.7291	0.4179	0.0518	0.8029	0.0001	0.0024	0.9109	0.3551			0.3678	0.6797		
Prob. for AxB (interaction) =	0.2053	0.3700	0.2084	0.2889	0.5985	0.1519	0.6517	0.7614			0.8878	0.8373		

The probabilities for nitrogen level and seed size is not as consistently significant as that of the yield response, however there is still significance seen. The fungicide shows again that there are not a lot of consistent trends occurring, 2005 shows a high significance in the TKW in FSJ as again 2005 represents a year of consistent and adequate rainfall, maximizing crop potentials.

Table 3. Malt barley percent plumps and percent protein response to applied Nitrogen

	2006 - FSJ		2005 - DC		2005 - FSJ		2003 - FSJ		2002 - DC		2002 - FSJ		Average	Average
	Plumps %	Protein %	Plumps %	Protein %	Plumps %	Protein %	Plumps %	Protein %	Plumps %	Protein %	Plumps %	Protein %	PLUMPS %	PROTEIN %
TABLE OF A MEANS														
140 lb ac N/ac	96.7	11.8	97.1	9.8	94.7	10.2		8.9					96.1	10.2
250 lb ac N/ac	96.6	12.0	97.0	9.7	95.0	10.0		9.2					96.2	10.2
360 lb ac N/ac	96.6	12.3	97.3	9.4	95.0	10.1		9.8					96.3	10.4
470 lb ac N/ac	96.9	12.6	96.9	9.6	95.1	10.1		9.3					96.3	10.4
580 lb ac N/ac	96.6	12.9	96.5	9.6	94.5	10.2		9.6					95.9	10.5
690 lb ac N/ac	94.1	13.1	96.6	9.6	95.8	10.2		10.5					95.5	10.8
TABLE OF B MEANS														
1 no foliar fungicide	96.5	12.4	96.7	9.6	94.4	10.1		9.7					95.9	10.5
2 propiconazole fungicide	96.0	12.5	97.1	9.6	95.6	10.1		9.4					96.2	10.4
CV =	2.89	4.20	0.69	4.63	1.14	2.77		4.72						
Probability for A (Nitrogen) =	0.3407	0.0002	0.2055	0.5351	0.2849	0.7880		0.0001						
Probability for B (Fungicide) =	0.4956	0.7843	0.0367	0.8975	0.0005	0.7206		0.1261						
Prob. for AxB (interaction) =	0.3519	0.6502	0.5999	0.7105	0.4891	0.2943		0.3479						

This table shows some of the higher numbers in the probabilities especially for nitrogen level, 2005 fungicide shows slight significance but only in that of the percent plumps. Once again no relationship is seen between the nitrogen level and the use of foliar fungicide. Data shows that there is no advantage to applying propiconazole as based on the poor probabilities of factor B.

CONCLUSIONS

Yield response saw the best results, increasing with the increased fertilizer application. Seed size as tested through percent plumps, thousand-kernel weight and hectolitre weights did not see any notable increases to an increase in nitrogen rate beyond the initial level of 40 pounds actual nitrogen per acre. With these minimal differences an optimal rate of nitrogen is hard to determine for optimum seed size except that there appears to be a trend suggesting a nitrogen rate around 60-70 pounds of actual nitrogen per acre for best results for optimum seed size. However, to obtain optimal yield 90 pounds of actual nitrogen per acre is what would be required, at least under ideal moisture conditions.

The application of nitrogen seems to have become a type of risk management. As shown in the data collected over this five-year trial, in years of prime conditions the addition of moisture provides great benefits. Without seeing an increase in the protein content and without sacrificing seed size, the yield is increased significantly with each incremental increase in nitrogen. Under drought condition the application of nitrogen can increase the protein content to unacceptable levels. This can be seen in the data collect from Fort St. John 2006, where a definite drought was experienced. This is also supported by found literature: drier conditions create higher protein content levels.

The fertilizer macronutrients phosphorus and potash were kept well balanced; nitrogen was applied and increased at the listed rates. Both phosphorus and potash were applied as required by the soil testing results completed in the spring prior to planting. This complete balanced nutrient package could possibly explain the excellent results that were achieved here in this dataset; often literature shows that the increased rates of nitrogen create undesirable seed size and protein content. This may also be explained by the rates of fertilizer used: higher application rates could have been tested.

The use of the foliar fungicide propiconazole has shown for the most part to be ineffective on such barley as AC Metcalfe. AC Metcalfe is known to provide a major improvement in genetic ability to resist attack from one of the most common leaf diseases of barley in the Peace River region, that of Scald, Rhynchosporium secalis (Oud.) Davis. Data from 2005 did show minimal response to the addition of disease protection, however not enough to justify the extra output costs. This comes at no surprise as the year 2005 represents a year with adequate an timely rainfall and thus significant foliar disease pressures were noted, even for more disease resistant cultivars like AC Metcalfe. As foliar fungicides like propiconazole are usually applied at the first sign of disease, it can become a management tool. With experience and/or professional help from qualified agronomists, the decision to spray or not can come based on predicted and witnessed disease levels at the time, and only be applied when conditions warrant its application. A set of conditions this five-year dataset would suggest had not been reached yet for the variety AC Metcalfe, even in 2005.

It should be noted too that each variety of barley has its own inherent disease resistance built into the plant through breeding efforts. Reference materials describing such characteristics should be sought before choosing a variety to grow for malt barley potential as one more criteria besides the sometimes all too important yield potential. It should also be noted that there perhaps could be more superior options available now for foliar disease protection in barley than that of propiconazole, but other foliar fungicide products were not compared or tested in this study.

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