WHEAT HIGH YIELD MANAGEMENT PROGRAM

Winter Wheat as a crop in this province fits in well as a rotation crop.

Wheat, until recently, had been under-managed and its full potential not achieved in most cash crop situations. Wheat, as a crop, can do well in low fertility situations and can give reasonable returns with very little input; however, this can be costly in that valuable yield potential is lost and wheat can mine the soil of nutrients, robbing the next season's crop potential. It must be understood that when we fertilize a soil we are feeding the soil, not the crop – the soil must feed the crop. A crop like wheat has large nutrient demands but its root system is able to give off an organic acid that will turn insoluble nutrients into soluble nutrients in the soil. This only depletes the soils nutrient reserves for future crops.

Wheat yields are influenced by a number of factors. Top management requires accurate records and proper timing of all inputs in order to get the maximum yield and quality that the market demands today.

Management of the crop is a year round process. This begins with fall application of fertilizer and seeding of the crop. The early development of the wheat crop in the fall may have a big impact on the yield and quality of the finished product.

In order to get the top yields you will need to have the uniform plant stand seeding at a rate of 30 to 35 plants per square foot that will produce 1 to 2 tillers for next spring. In order to get greater than 100 bu per acre of wheat we will need 60-70 tillers per square foot with greater than 30 kernels per head with a test weight of 35 grams/1000 kernels.

Once we have the proper plant stand, disease and weed control in place, we can look at the nutrition of the crop at the various stages that are necessary to get top yields. The following is a table from the A&L Agronomy handbook that demonstrates the amount of nutrients that are removed by the crop. In order to get the nutrients into the crop they must be supplied by the soil program that we have put in place. Remember that the amount that is removed by the straw needs to be accounted for even if it is plowed down since it will be contained in the straw until the straw breaks down and returns these nutrients to the exchange complex. This is difficult to estimate and we should use a soil test to determine what the soil nutrient levels are.

APPROXIMATE POUNDS OF NUTRIENTS REMOVED BY A WHEAT CROP BUSHEL

	N	P	K	Mg	Ca	S
GRAIN	**1.6**	**.6**	**.4**	**.14**	**.05**	**.10**
STRAW	**.5**	**.12**	**1.2**	**.10**	**.21**	**.13**
TOTAL	**2.1**	**.72**	**1.6**	**.24**	**.26**	**.23**

SOIL pH CALCIUM

As for most crops the optimum pH for wheat is 6.5. At this pH most nutrients are soluble and available to the plant given that there is enough soil moisture and air movement in the soil. At this pH root growth is close to optimum as well.

If the pH of a field, on a soil test, is not at 6.5 it should be limed to bring it to the proper pH. In cases where a lot of lime is required it is recommended that this application be done in stages so that we do not over correct the situation and tie up other nutrients in the process.

NITROGEN

Nitrogen management of the wheat crop is well defined due to the nature of the growth phases and timing of Nitrogen needs by the plant. Improper application may result in promoting the wrong growth at the wrong time and will increase disease pressure such as mildew and rust. If Nitrogen is applied at the right time, however, it will not promote vegetative growth but will increase tillering and protein content. The forms of Nitrogen applied are also important because some forms of Nitrogen may not be readily available in cold soil conditions.

The soils ability to hold Nitrogen also becomes a factor due to the requirements for Nitrogen to finish the crop and increase the protein if protein is a factor in your quality. We use CEC and organic matter of the soil to determine its Nitrogen holding capacity. This is just a guide but gives us a better understanding of the Nitrogen placement in different soil types (Table #1).

Table #1
COMMON FACTORS USED IN CALCULATING NITROGEN HOLDING CAPACITY OF SOILS

ORGANIC MATTER	FACTOR USED
0-1	7
1-4.9	8
1.5-2	9
2+	10

FORMULA FOR DETERMINING NITROGEN HOLDING CAPACITY

Organic Matter factor x CEC – Nitrogen holding capacity

i.e.: CEC = 8 %OM = 1.5

8 x 9 = 72 pounds of Nitrogen applied in one application that this soil can hold

The Nitrogen requirement of wheat in the fall is minimal due to the relatively small amount of vegetative growth that takes place before dormancy. Approximately 20-30 pounds of Nitrogen is sufficient to get it through the fall.

Early Application of Nitrogen (Prior to tillering GS 25 or Feek's 3)

- **If the wheat plant does not have adequate supply of Nitrogen early it will not tiller. If a crop has greater than 80 heads per square foot an early application of Nitrogen may not be needed**

The next application of Nitrogen is very critical and the form used is also a factor. Early application of Nitrogen prior to tillering (GS 25 or 3 on the Feek's scale) is important to promote tillering. If the wheat plant does not have an adequate supply of Nitrogen early it will not tiller and we will not get the amount of heads per square foot that will give us the yield advantage.

A very early application of Nitrogen helps us to manipulate the tillering process in the spring, which will help us achieve the higher yields. If the Nitrogen application is missed and all of the Nitrogen is applied to the crop after the tillering stage it will only promote vegetative growth and might increase disease pressure.

If the crop already has greater than 80 heads per square foot an early application of Nitrogen may not be necessary, however, depending on the soil type it may be advisable to split the Nitrogen for best efficiency and to reduce loss to leaching.

Usually in our climate it is best to have a program in place to apply Nitrogen early before we can determine the amount of tillering. This way we do not miss this stage due to poor soil conditions in the spring. Also, it is easier to apply Nitrogen on frozen ground early so that we do not miss this stage due to wet soils.

The amount of Nitrogen to apply at this time would be approximately 35 to 40% of the total Nitrogen required for this crop. The Nitrogen application ideally should contain a good portion in the form of Nitrate so that it will be available to the plant in cold soils. Please remember Urea will need to be broken down by soil organisms to be converted to the NO_3 form and this may not happen fast enough in cold soils to get it to the plant to promote tillering. With warm soils Urea works very well.

The next application of Nitrogen should be applied just before stem elongation (GS 30 or Feek's 5). Research has proven that Nitrogen application at this time is required for optimum Nitrogen levels in the tissue for the remainder of the growing season. A tissue test at this time is a good management tool to determine the nutrient status of the crop.

If the crop is priced for protein content it may also be beneficial to supplement the Nitrogen program with a foliar Urea application at this stage. Sulfur can be applied with the Nitrogen to help reduce mildew pressure. If a foliar program is to be used tramlines should be established in your program. The use of tramlines will reduce the potential for disease caused by driving over the wheat particularly at the jointing stage. Urea should be used as the foliar Nitrogen source because it is less phytotoxic to the plant than other sources of Nitrogen and should never exceed 5 pounds of Nitrogen per acre application.

Balancing the actual demand for Potassium by wheat and the estimated availability of Potassium is sometimes a difficult task. Research has shown that applying Potassium with this application of Nitrogen on the form of KCL will help reduce disease in the wheat crop and also reduce the potential for lodging. KCL will also reduce potential for Nitrogen loss due to volatilization in top dressing. It is recommended that approximately 40 pounds/acre of Potassium to be applied at this time.

FORMULA FOR CALCULATING NITROGEN REQUIREMENT

1.5 x Yield Goal – (5 x %O.M.) + or – previous crop Nitrogen credit

Previous crop Nitrogen credit: Corn + 20, Wheat +20, Beans -10
Maximum Nitrogen credit for organic matter is 30 pounds

PHOSPHORUS

Wheat has a high demand for Phosphorus as you can see by the removal chart. However, we know through research trials that wheat will grow well when Phosphorus is not supplemented in the fertilizer program. This is due to the wheat's ability to mine Phosphorus from the soil. Wheat's roots exude an organic acid called MALIC ACID that actually dissolves Phosphorus that is bound by the soil and would not otherwise be available to the plant. This ability to forage for Phosphorus will help the wheat plant but it leaves the soil in a greater deficit for the next crop.

Building Phosphorus levels and maintaining them is a long process and it is good to at least supply the crop requirements in early season. Phosphate is required for early root development, plant growth and seed development. A wheat plant will take up 65% of the total Phosphorus requirements by the time it reaches the boot stage.

Although most of the Phosphorus requirements can be put on as a broadcast application in the fall during seedbed preparation, it is good to apply some Phosphorus, 20 - 30 pounds/acre, at planting time to make sure that the small developing root will be able to reach Phosphorus early.

In the soils where Phosphorus levels are low or for high production wheat with soils less than 30ppm of Phosphorus bray 1, an application of Phosphorus in the spring with the second Nitrogen application has shown a significant response in root growth, quality and yield. Growers show response by using a triple blend at this time such as 19-19-19 to supply the remainder of the Nitrogen requirements.

POTASSIUM

Potash is vital for opening leaf pores (stomates) so that carbon dioxide gets into leaves to build sugars and protein. Potash also helps build strong stems against lodging as it is critical in cuticle formation.

Since the cuticle is the first line of defense for any crop, increased potash levels in wheat reduce the incidence of powdery mildew. Higher potash levels in the plant also control other stimulus in the plant that it needs to react to daily environmental influences.

Wheat absorbs approximately 90% of its potash by the boot stage. The greatest daily uptake of Potash is 2.5 lbs./acre and occurs during the time from tillering through to the boot stage.

After making a recommendation, from the charts based in the soil test levels of Poor, Medium, Good and High it is important that you ask the following questions about the history of the field. **Was the last crop maturity satisfactory? Was there any lodging in corn or grain in the previous crops? What was the disease pressure like in the last crops?** If the answer to any of these questions was **YES** it may indicate that Potassium levels are low or the availability of potassium is low. This means that the % saturation of Potassium in this soil type may need to be higher to ensure the Potassium is available and your recommendation for Potassium in this crop may need to be increased or you may want to apply Potassium more frequently as was discussed in the Nitrogen section.

MAGNESIUM

Good levels of Magnesium must be maintained in order to uptake Phosphorus. Therefore, we will shoot for approximately 14% saturation of Magnesium in the soil for optimum Magnesium. Without

good Magnesium levels diseases such as take-all may be a problem. Magnesium is required in the uptake of Phosphorus and if Magnesium is low, grain may not mature properly or we may have an increased level of poorly formed heads.

In some soils this may not be possible because of the high Calcium. Therefore, we will add additional Magnesium in the planter mix. Magnesium is the main element required in the production of Chlorophyll. The use of Sulfate of Potash Magnesia in the split Nitrogen program will supply a good source of soluble Magnesium to the crop.

CALCIUM

Calcium is required for the production of all meristimatic growth. The root hairs of a plant contain a lot of meristimatic tissue. To have good root growth ideal calcium levels in the soil are critical. Calcium binds plant cells together and is important in the construction of cell walls. Without adequate calcium new cells cannot be created and growth will stop.

In most cases, for wheat production, it is not profitable to add additional Calcium to the mix and, if needed, it will usually come from a lime application to correct for a low pH. The calcium level of most soils for optimum plant growth is 60 – 80% will be more ideal.

The MEY club of Kent County has shown, even in high calcium soils, that with high yields often times calcium will become the limiting factor.

SULFUR

A deficiency of sulfur can cause accumulation of non protein Nitrogen in plants, which can be detrimental to ruminant animals if it is not corrected by feeding supplements containing sulfur in either the organic or inorganic form. Ruminants are able to utilize sulfate, sulfide and to a lesser extent, elemental sulfur in the synthesis of proteins. Non ruminants cannot and must have methionine in their diets.

In non-leguminous plants that have been given liberal quantities of Nitrogen fertilizers, Nitrates as well as amides may accumulate in the tissues. Nitrates in large quantities are toxic to animals. If sulfur is limiting, Nitrates accumulate in plant tissue.

Sulfur not only plays a major role in plant growth and metabolism as a nutrient it also has pronounced effect on soil chemistry and the availability of other nutrients.

Tests have shown inter relationships between high soil level Phosphorus, Sulfur, Magnesium and Zinc. Where soil Phosphorus levels are high and soil Sulfur levels are low we have often noted low tissue Magnesium levels even though the soil Magnesium is abundant.

The application of Sulfur with proper placement has not changed tissue Sulfur levels to any marked degree but has raised the Magnesium levels in plant tissue. In the soil environment, the application of the acid forming Sulfur may be causing the release of Magnesium that has been tied up by the Phosphorus.

Another case more typical to Ontario soils is the competitive effect between Potassium and Calcium and how it can influence crop quality and yield. High Calcium levels in soil interfere with the uptake of Potassium especially early in the growing season when Potassium is so important.

The addition of straw with a low Sulfur content to the soil used will tie up the available soil Sulfur because of the immobilization by soil microorganisms during decomposition of the straw. This situation is aggravated by the addition of fertilizer Nitrogen that further widened the Nitrogen:Sulfur ratio in the soil.

In the case of wheat production with the addition of straw to the soil, to which no Sulfur was added, there is a progressive decrease in the growth of the wheat plants. The addition of Sulfur in the fertilizer will overcome the limiting effect of the straw.

Sulfur is vital for building protein, utilizing soil and fertilizer Nitrogen and improving milling quality. Wheat requires most Sulfurs between the tillering and boot stages.

Requirements for this nutrient are dependent on Sulfur levels in the soil plus Calcium levels. If Sulfur is less than 25ppm add approximately 1 - 15 pounds per acre for Sulfur nutrition. In some cases even where Sulfur levels are high we do get a yield response from additional Sulfur. If Calcium % saturation were greater than 80% it is suggested that 10 pounds of elemental Sulfur in the row to aid in the uptake of Potassium, Magnesium and Phosphorus. This application works well in soils with high CEC such as soils with CEC greater than 25 or soils with greater than 20 and low organic matter. This form of Sulfur, however, only works as elemental Sulfur and does not seem to work with Sulfur coming form Sulfate of Potash Magnesia sources as it would if we just needed Sulfur as a nutrient.

Foliar Sulfur application with or without Nitrogen application has shown a reduction in the incidence of powdery mildew in wheat. Sulfur application from other sources such as Sulfate of Potash Magnesia or Ammonium Sulfate will supply good levels of sulfur and increase protein levels.

BORON

Boron is leached readily from soils and the courser the soil (the lower the CEC) the faster the Boron will leach from these soils. Boron's function in the plant is primarily that of a catalyst for most other nutrients. In other words, it completes a chain of chemical reactions in the life cycle of a plant. Three major nutrients that Boron influences in the uptake are Phosphorus, Potassium and Calcium.

Boron, however, is very toxic if over used. Therefore, application is sometimes difficult. To blend 1 lb/acre in most mixes it is difficult to get a uniform distribution. To avoid this problem it is recommended that a soil application of Boron at 1 lb/acre as Sol-u-bor (5 pound of material), preplant incorporated or pre emerge. (Can be applied with most herbicides).

In cases of severe Boron deficiencies follow up spray with foliar Boron 2 to 3 times depending on tissue levels. In order for Boron foliar to be effective a soil application must also be in place.

ZINC

Zinc is required in the plant to ensure early emergence and good leaf area. When applying Zinc to a crop it is more important in the early planting and in cold soils even when Zinc levels are good. If applying Zinc to soils where Zinc is medium to low, make sure that Zinc is applied at 1 pound for

every 10 pounds of Phosphorus that is put in the planter to make sure adequate Zinc will be available in theses cold soils. If Zinc levels are good to high apply Zinc at 1 pound for every 20 pounds of Phosphorus applied in the planter, Zinc should always be applied in the planter and always as a Zinc sulfate source. If a starter mix is not used and Zinc levels are low the best response to Zinc is a foliar feed as soon as there is leaf enough to spray.

MANGANESE

Wheat is highly responsive to Manganese and it should be applied to the planter mix at levels recommended by the soil test. Manganese, however, will convert from the available form in the soil and become unavailable to the plant. In some soils deficient in Manganese it may be necessary to follow up with a foliar spray as well, both in the fall and again early in the spring in very deficient soils. Again, if a planter mix is not used it is important to foliar feed as soon as there is leaf area to spray.

On very low soils it is a good practice to build these levels. Although this application is not cost effective in years of building, once these levels are at 33ppm additional Manganese should not be required. Experience in building soil levels in most cases has shown an application of 15 pounds of Manganese for three consecutive years will build to these levels.

COPPER

In the past a soil level of 1ppm has been adequate for crop production. Recent information from research indicates that a level closer to 3ppm may be more in line with what the wheat crop requires. Copper helps the uptake of Manganese which in turn promotes better lateral root growth early.

Copper also reduces fusarium infection in wheat in years where fusarium conditions are favourable. A plant that has adequate levels of Copper will have tighter glumes and infection is not as likely.