Instructions for Using the Maximum Return to Nitrogen (MRTN) Concept in Nutrient Management Planning

Corn is a highly efficient plant that can generate large amounts of biomass (grain and stover) in a very short period of time. Maximum productivity is dependent on adequate plant populations, minimal pest infestations and, an ample supply of nutrients and water. Productive corn crops take up large amounts of plant nutrients. The greatest of which is nitrogen. A high yielding corn crop can accumulate upwards of 275 lbs. N/acre at physiological maturity with approximately one half of the total in the grain. Corn obtains much of the needed nitrogen from soil derived sources such as native organic matter, decaying crop residues, manure, and nitrogen fixed by legumes. It is however very difficult to predict how much nitrogen will be available from soil derived sources. The amount of plant available nitrogen released from the soil is dependent on moisture, temperature, and other factors. Moisture and temperature are highly variable from season to season and also within a growing season. Additionally, nitrate nitrogen from all sources is subject to leaching and/or denitrification losses during wet periods. Profitable corn yields in most years can only be obtained with supplemental nitrogen fertilization. On the average, unfertilized corn fields lacking a manure and/or perennial legume history will only yield a little over half of the economic optimum yield where corn follows corn and roughly 70 percent of the economic optimum yield where corn follows soybeans.

Due to the uncertainty in predicting the amount of soil derived, plant available nitrogen and lack of a reliable, widely accepted nitrogen soil test for fields without a recent manure or legume history, most Corn Belt states have used a yield based nitrogen recommendation system. Decades of research in Illinois on the effect of nitrogen rate on corn yields determined that on average the optimum nitrogen rate at the optimum yield consistently resulted in a factor of 1.2 lbs. of N per bushel of corn produced. In Illinois, base nitrogen recommendations were calculated on an expected yield times 1.0 to 1.3 depending on the price ratio between nitrogen and corn. Adjustments were made to the base recommendation where corn followed soybeans or legumes such as clover or alfalfa and when other relevant nitrogen sources were present.

Modern corn hybrids possess traits that have allowed farmers to produce significantly higher yields. The newer hybrids are more productive but average protein content in the grain is often slightly lower. Consequently, it takes less nitrogen per bushel of corn produced. The price of natural gas, a precursor in the manufacture of many nitrogen fertilizers, has been volatile in recent years. The result has been sharp increases in the retail price of nitrogen fertilizer significantly increasing the cost corn of production. Most nitrogen rate experiments demonstrate that corn yields increase as nitrogen rates increase up to a certain point. Increasing nitrogen beyond the point results in an insufficient yield increase to pay for the last added nitrogen. Additionally, there is greater potential risk of nitrate loss to the environment when nitrogen from the soil and/or fertilizer is at levels higher than the corn crop needs for economical yields. The nitrogen fertilizer rate that achieves the maximum monetary return is called the Economically Optimum Nitrogen Rate (EONR) or Maximum Return to Nitrogen

(MRTN). The yield obtained at the EONR is called the Optimum Yield. Due to variability in the amount of soil derived, plant available nitrogen mineralized each year and the efficiency of modern corn hybrids, there is almost no relationship between optimum yields and the amount of nitrogen it takes to obtain them. In other words, the amount of nitrogen fertilizer applied fails to be predictive of the eventual yield of the corn crop. The above factors have resulted in changes in nitrogen recommendations by several universities in the US Corn Belt. Due to the economics of fertilizing corn and potential environmental impacts, it makes prudent sense to provide nitrogen to a corn crop only in the amounts necessary to generate the maximum return from the investment in nitrogen fertilizer. The resulting nitrogen recommendations are generally lower than those developed using the yield based methods. The new recommendations in Illinois are based on more than 400 trials in Illinois where the corn yield response to incremental increases in nitrogen rate was tested. The generated response curves are used to calculate the Maximum Return to Nitrogen based on the ratio of nitrogen to corn prices. To assist producers in calculating the MRTN, a regional website was created and can be found at: http://www.extension.agron.iastate.edu/soilfertility/nrate.aspx

The calculator found at the website prompts the user to enter a price(s) for corn and nitrogen. The site then calculates a range of nitrogen rates that represent a return above and below the MRTN by one dollar/acre based on the ratio of nitrogen to corn. Selecting a nitrogen and corn price for nutrient management planning is not a straightforward process as they both fluctuate over time. Farmers seldom receive a single price for every bushel of corn they sell as they often to use multiple pricing techniques that help hedge against large swings in commodity prices. Farmers do however typically attempt to lock in a single price for nitrogen fertilizer materials as they tend not to purchase fertilizer throughout the year. There are no specific criteria or “rules” for selecting nitrogen and corn prices for nutrient management planning. In order to analyze how nitrogen recommendations might fluctuate, corn and nitrogen prices were obtained at two week intervals for calendar year 2010. Average corn prices ranged $3.22-$5.89 per bushel and average anhydrous ammonia prices ranged $ 516.80-$774.75 per ton (data not shown). Below is a graph showing how the nitrogen to corn price ratio fluctuated throughout 2010. In spite of rather wide swings in prices of both commodities, the ratio of the two remained steady between the values of 0.08 and 0.10. The nitrogen calculator derived an MRTN rate for the two ratios of 185 and 194 lbs. N/acre, respectively for corn after corn in central Illinois. The previous yield based system for a 180 bu. /acre corn after corn generated a recommendation of 216 lbs. N/acre. Future nitrogen and corn prices cannot be forecasted with utmost accuracy but the ratio between the two is not likely to fluctuate greatly during a given crop year indicating that frequent revisions of nutrient management plans will not be necessary nor practical. In the near term, using nitrogen to corn price ratios between 0.08 and 0.10 will likely capture most nitrogen and corn price scenarios. The ratios are used to plan nitrogen rates where commercial fertilizer and manure are the primary sources of supplemental nitrogen. When using manure as a source of nitrogen, a laboratory test is necessary to determine how much of the manure nitrogen is in the ammonium form and the organic form. Estimates of the available nitrogen in the year of manure application can then be made.

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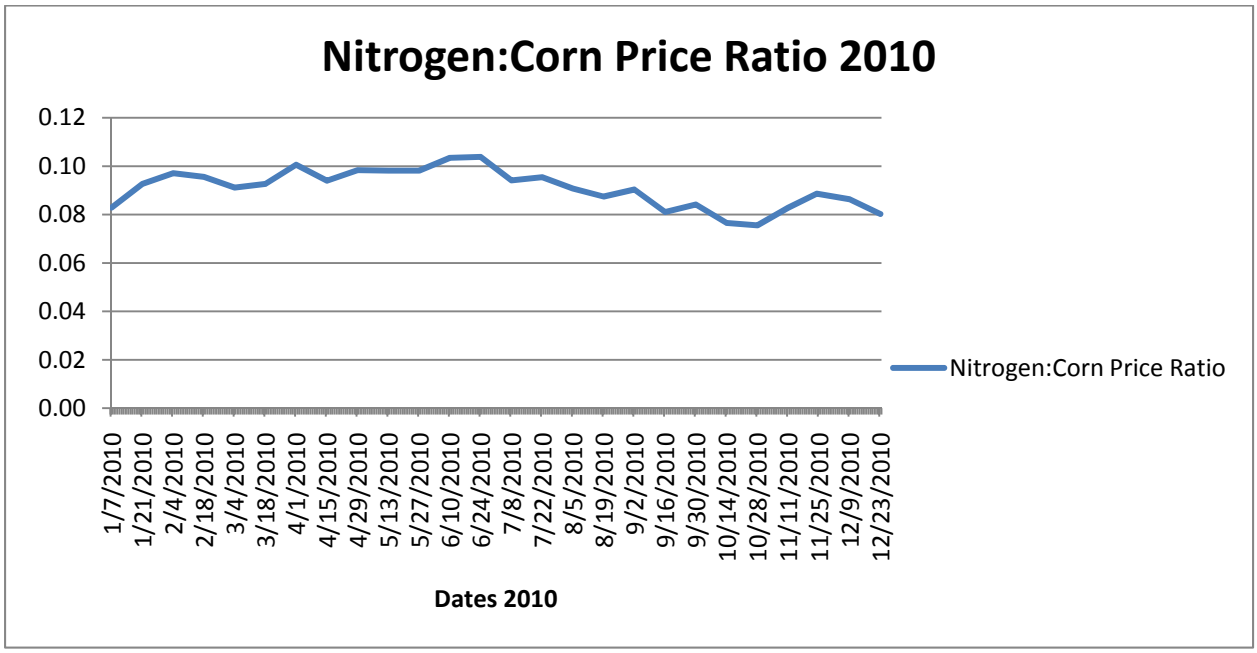

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USDA Agricultural Marketing Service Report GX_GR 113

USDA Agricultural Marketing Service Report GX_GR 210

http://www.extension.agron.iastate.edu/soilfertility/nrate.aspx