# Special Field Crop CAT Alert edition: Another look at fertilizers

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Articles compiled by the **MSU Extension Field Crops Area of Expertise Team** and Natalie Rector, issue coordinator. Visit http://www.ipm.msu.edu/fertilizer2009.htm to read the issue online.

## Contents



## Another look at using fertilizers

A word to the wise: question everything these days. Our reasoning powers that worked in the past are strained today. Farmers used to watch the Chicago Board of Trade for commodity prices; today they watch the price of gas at their local fuel station to gain some sort of rationale for how much fertilizer will cost and what the price of grain will be in the coming year. While change may be risky, not changing may be even more risky.

In 2008, fertilizer and commodity prices proved how volatile and irrational markets can be. Nitrogen and phosphorus prices have been coming down, but they are still twice what they were several years ago while the price of potash has quadrupled. It's time to question everything, including the way you have always fertilized crops. Could you be just as successful in harvesting high yields with lower fertilizer inputs? Could even a small change add up to large savings? If you find only one "keeper" idea in this article, it will pay to read on.

### Starting point

Soil test, soil test, soil test! Check your pile of soil test reports. How old are they? Do you have current reports for all fields? It's impossible to properly manage soil nutrient levels if there isn't any information to formulate recommendations.

### Compaction

It doesn't matter if you take your own soil samples or hire someone else to take them, but a lot can be learned about the status of your ground by collecting your own samples. If you have difficulty getting the soil probe 8 inches deep, as recommended, soil compaction may be limiting the crop's ability to absorb water and nutrients. Reducing fertilizer on such fields will be risky until the compaction issues are resolved. Compacted areas may also cause ponding, which can result in denitrification of N, losing that nutrient up into the air.

### pH and micro nutrients

Applying micronutrients is economically beneficial only when a deficiency has been identified in a field. Applying any amount of micronutrient is expensive if need has not been determined. However, soil tests can indicate where potential micronutrient deficiencies are more likely. Compare the pH on your soil tests to the following targets for optimum nutrient availability. For a complete listing, visit http://www.emdc.msue.msu.edu/mainsearch.cfm type E2904 in the inventory number box to search for Nutrient Recommendations for Field Crops in Michigan. Or click on the link for a complete PDF copy.

| Crop | Optimum pH on mineral soils | Optimum pH on organic soils |
|---|---|---|
| Alfalfa | 6.8 | 6 |
| Beans: dry edible and soybeans | 6.5 | 5.8 |
| Corn | 6.5 | 5.3 |
| Sugar beet | 6.5 | 5.5 (beets are not recommended to be grown on organic soils) |
| Wheat | 6.5 | 5.8 |
| Grass Pastures | 6.5 | 5.3 |

When soil structure and pH meet requirements, it is less risky to reduce fertilizer. pH impacts the availability of all nutrients. Low pH can inhibit not only nitrogen (N), phosphorus (P), and potassium (K) but also magnesium (Mg). Use dolomitic lime to increase pH and also supply magnesium. Boron (B) can be a concern on alfalfa, especially on sandy soils.

On high pH soils, zinc (Zn) and manganese (Mn) are generally the first micronutrients that are limited. If you determine a need for micronutrients, purchase only the ones your soil test shows are needed. Generally, soil has abundant supplies of these nutrients for crops; let the soil do its job.

### Cutting nutrients based on new additive products

If it sounds too good to be true, maybe it is. A common sales angle is to suggest that using a particular product will allow a farmer to succeed with reduced nutrient values. Do you want to swap your known nutrients for unknowns when every drop counts? When confronted with new products that are unfamiliar to you, ask for independently verified research results that include statistical analysis. Many of these products induce variable results, so wild swings can be seen in numerical yields. Demand evidence of consistent, statistically significant results. Iowa State University houses a web site for the North Central region on soil additive and growth stimulant products at www.agronext.iastate.edu/soilfertility/nutrienttopics/addbyproducts.html. Or contact your local extension educator or campus specialist. Many of these products have been tested by universities in the North Central region, including Michigan State University.

## Too little or too much nitrogen on corn: MSU's new guidelines

The economic risk of applying too much nitrogen (N) on corn is just as dramatic as applying too little. In 2004, university agronomists from the North Central region began a project to determine maximum agronomic production of corn at the most efficient economic level. The Maximum Return to Nitrogen (MRTN) approach to corn N recommendations represents the combined efforts of six states to develop the most efficient and profitable system of N management based upon site-year information. The recommendations utilize the latest hybrid genetics, soil productivity qualities, and best N management practices.

This new method will probably seem radical to many and risky to most. If it does nothing other than make you rethink your N rates and contemplate the price of corn, it will be worth the time to see how your current thinking compares to the following charts.

Michigan's corn N response database includes 47 site locations over the last ten years, including 30 in the last three years. Statistical modeling is used to fit response curves to each individual site's corn grain response to N. Response to N is calculated at 1 lb N rates along that curve to find the most economic application rate. All sites are then combined to generate the most profitable N application rate, or MRTN. These trials were conducted with spring pre-plant, sidedress, or split preplant/ sidedress applied N, and sites were not irrigated. The current MSU guidelines from these trials are shown in Table 2.

### Calculating the N:corn ratio and the price of N per pound

The multitude of possible N and corn grain price ratios make computer spreadsheets an ideal tool to determine specific corn N rate recommendations. Visiting this calculator, http://extension.agron.iastate.edu/soilfertility/nrate.aspx, will stretch everything you thought you knew about economics and corn's response to nitrogen. The Michigan data will be at this site by mid-February. An example of the type of data generated by this calculator is shown in Table 1.

The N rate calculator begins by calculating the **N:corn price ratio** by dividing the price per pound of nitrogen by the price per bushel of corn.
First calculate the price of N on a per-pound-of-nutrient basis.
To compute the actual cost per pound of nutrient of various fertilizers, use the following formulas:

Material price per ton ÷ (2000 x % analysis of product) = nutrient cost in $ per pound of nutrient
For example: urea at $350 per ton ÷ (2000 x 0.46) = 38 cents per pound of N
Another example: 28% at $200 per ton ÷ (2000 x 0.28) = 35 cents per pound of N

When nitrogen is calculated on a per-pound basis, you can also compare the major N sources on a cost per pound of nitrogen. If anhydrous is $750 per ton, 28% UAN is $250 per ton and urea is $420 per ton, the result for all of them is about $0.46 per pound of actual N.

Next, compute the N:corn price ratio.
Example: Urea at $370 per ton is $0.40 per pound of N ÷ $4/bu. expected corn price = 0.1 N:Corn price ratio.

Once you have the N:corn ratio, use the MSU chart below (Table 2) to see what rate of nitrogen is considered the Maximum Return to Nitrogen, considered the most economical rate of nitrogen to use for the given yield potential.

**Table 1. Range of Economic Optimum N Rate values (lbs/ac applied N) for corn following soybean as influenced by N cost per lb. N and grain price per bushel.**

| | Price of corn grain | | | | | | |
|---|---|---|---|---|---|---|---|
| **N cost** | **$3.00** | **$3.50** | **$4.00** | **$4.50** | **$5.00** | **$5.50** | **$6.00** |
| **$0.40** | 93 | 97 | 100 | 102 | 104 | 105 | 107 |
| **$0.45** | 90 | 94 | 97 | 100 | 102 | 104 | 105 |
| **$0.50** | 87 | 91 | 95 | 98 | 100 | 102 | 103 |
| **$0.55** | 84 | 89 | 92 | 96 | 98 | 100 | 102 |
| **$0.60** | 80 | 86 | 90 | 93 | 96 | 98 | 100 |
| **$0.65** | 77 | 83 | 87 | 91 | 94 | 96 | 98 |
| **$0.70** | xx | 80 | 85 | 89 | 92 | 95 | 97 |
| **$0.75** | xx | 77 | 82 | 87 | 90 | 93 | 95 |
| **$0.80** | xx | xx | 80 | 84 | 88 | 91 | 93 |

This is the average N recommendation. For +/- $1 of the MRTN, the recommended N rate will range from 10 lbs less to 15 lbs more than the value in the table.

**Table 2.**

| **Michigan State University Corn Nitrogen Recommendations** | | | |
|---|---|---|---|
| **N:Corn Price Ratio** ⇨ | 0.10 | 0.15 | 0.20 |
| **Yield Potential** Previous Crop | **Recommended lbs. of N per acre** | | |
| **Medium/Low** | **Rate** *Range* | **Rate** *Range* | **Rate** *Range* |
| Corn | **130** *115-145* | **120** *105-135* | **110** *95-125* |
| Soybean | **100** *85-115* | **90** *75-105* | **80** *65- 95* |
| **Very High/High** | | | |
| Corn | **150** *135-165* | **135** *120-150* | **120** *105-135* |
| Soybean | **115** *100-130* | **105** *90-120* | **95** *80-110* |
| *Range: approximates ± $1.00 of the Maximum Return to N rate* | | | |

### Be sure to credit N from previous sources

Response data for these N recommendations was based on soybeans or corn as a preceding crop. Other crops in rotation with corn will require adjustments in the N credits applied to this recommendation. Be sure to credit all potential nitrogen that may be available for corn production.

### Alfalfa

Even a worn out alfalfa crop has N value to the following corn crop. A 50 percent stand should contribute 90 lbs per acre of N to the following corn crop, but the better the stand of alfalfa, the more N potential.

### Clover

Clover cover crops often provide 50 to 70 lbs per acre of N the following season. The thicker the stand and the more growth that occurs before it is killed, the more N potential left to the following crop. To learn about frost seeding clover into wheat, visit www.animalagteam.msu.edu/LandApplication/CoverCrops/tabid/215/Default.aspx

### Soybeans

Soybeans are generally credited for 30 lbs per acre of N to the following corn crop. However, when using the MRTN data base for corn after soybeans (Table 1), no additional N credit should be taken -- that would be double dipping. This N benefit is because soybeans are N fixers and have less residue compared to corn after corn. Therefore, less N is tied up in decomposing the residue and more N is readily available for the following crop. Corn following soybeans should need less N than corn following corn.

### Wheat

When planting corn after wheat, the corn/corn rotation N recommendations should be followed.

### Manure

Manure has several years worth of slow release organic N. The application rates and manure analysis can be used to estimate these amounts while pre-sidedress nitrate soil tests will measure the plant available nitrogen for the current season with greater accuracy. More specific information on manure can be found at www.animalagteam.msu.edu.

## Weeds rob nitrogen from corn

An MSU timing study on post emergent weed control showed that 95 percent of weed control or better can be achieved when weeds are 9 inches tall, but yields were reduced 25 bushels per acre. (Everman et al., 2008)

Post-emergent herbicides provide a greater window of opportunity to control weeds, but allowing weeds to grow too long can be “robbing” N and other nutrients from the intended crop.

In a two-year study in Wisconsin, there was no yield loss when weeds were controlled at the 4-inch stage, but delaying application on 12-inch weeds resulted in an average 9 percent yield loss. Looking at the data from another view point, 2006 data showed the MRTN rate was 96 lbs per acre when weeds were controlled at 4 inches, compared with an MRTN rate of 200 lbs per acre when weeds were controlled at 12 inches. Timely weed control will ensure valuable nutrients are used for crop production rather than weed production. (Boerboom et al., 2008.)

## Managing nitrogen fertilizer for greatest efficiency

Hopefully you have experienced a year when corn yields exceeded the nitrogen applied. Soil N can provide as much as half of the total N available to the crop. (Camberato et al., 2008.) Rain and sunlight are often the two most sought after resources for high yields, and when these two resources are abundant and timely, plants seem to find the additional nutrients to exceed yield expectations.

However, excess rain has an impact on potential N losses; on sandy soils downward leaching can occur while prolonged standing water on heavy soils can cause denitrification (losing N up into the air). These excessive rains often come early in the season, after N fertilizers have been applied, but prior to maximum uptake by plants.

### Timing of N application and N source

The rule of thumb is still true: uptake of fertilizer N is most efficient when applied as close as possible to the time of a corn plant needing it. Some forms of N are more suitable for application at planting while others are better suited for sidedress applications. Even when your situation does not allow for the greatest timeliness, there are factors to consider to decrease N losses and increase N uptake by corn.

### Urea (46% N)

When urea dissolves, it is converted by the enzyme urease to ammonium and bicarbonate, creating an alkaline environment where ammonium is converted to ammonia ($NH_3$). This production of $NH_3$ occurs naturally in soil and on plant material. For surface applied urea fertilizer, the goal is to decrease the amount of ammonia going up into the air and being lost (a process called hydrolysis). Warm temperatures and moisture accelerate this process.
Several research studies have found the following about broadcast urea at various temperatures:

- At 35°F 50 percent can hydrolyze within 4 days and by 10 days, 100 percent hydrolysis.
- At 50°F, half of the urea can hydrolyze in 2 days and 80 percent within 4 days.
- At 79°F, 90 percent can hydrolyze within 2 days.

**When immediately incorporated into the soil, these losses can be reduced to virtually zero.** (Bundy, et al., 2001)

Light rainfall can cause urea to move into the soil protecting it from ammonium-N losses. As little as 0.1 inch of rain can minimize ammonium-N losses and 0.2-0.5 inches within 24 hours after urea application usually prevent volatilization. (Bundy, 2001). Rainfall or irrigation moves the dissolved urea into the soil where ammonium will be held on the exchange sites of clay and organic matter.

Urea-N can be converted to nitrate-N ($NO_3$-N) in less than two weeks in late spring. At this point, the $NO_3$-N is susceptible to leaching if excessive rain occurs, especially on sandy soil.

A soil pH of 7 and higher can also accelerate loss of ammonium-N into the air when urea is surface applied. Do not surface apply urea if lime has also been surface applied within the last three months as this can increase $NH_3$ volatilization losses. Incorporation of lime and/or urea will reduce these potential N losses, especially on high pH soils.

In summary, the worst case scenario for urea losses into the air is a surface application with no incorporation onto a high-residue field, when it is warm and sunny, and the soil pH is greater than 7.

Another potential high loss scenario would be applying urea early, even when incorporated, on sandy soils followed by excessive rains before peak crop demand. In this case urea is applied too early and has time to convert to nitrate-N.

### Anhydrous ammonia (82% N)

Generally, anhydrous ammonia ($NH_3$) is the cheapest source of N per pound of N and must be knifed into the soil. Wet soils may hinder the soil sealing behind the knife injection slot, resulting in N losses. Deeper injection (6 inches) is best on both dry and damp soils to prevent losses.

Anhydrous quickly converts to ammonium-N which is held tightly to the soil, eliminating leaching or volatilizing. However, $NH_4$-N then converts to nitrate-N which can be leached. This conversion happens faster in warm temperatures. Fall applications of N are not recommended, but if they must be, it should be as anhydrous and applied after the soil temperatures are below 50°F and predicted to stay cool. Under spring conditions, the conversion generally happens in a week to 10 days when soil temperatures are above 50°F. This is why pre-plant applications are not as efficient as at-planting, which aren't as efficient as sidedressing. Ammonia's effects on soil microbes within the application band acts as its own nitrification inhibitor for at least a week. Periodic winter thaws and abundant soil moisture make anhydrous applications susceptible to overwinter N losses. As a result, fall anhydrous ammonia applications are not recommended in Michigan.

### UAN solutions (28%-32% N)

Urea and 28% UAN will cost less per ton of material, but more per pound of N. The higher cost may be partially offset by lower application costs. As a mixture of ammonium nitrate and urea, UAN already has a portion of its N in the nitrate-N form, which could leach if applied early, on sandy soils and if heavy rains occur. The urea portion requires banding, injecting or incorporating to keep from losing N into the air and makes UAN a good N source for sidedressing. Again, all the conditions discussed for urea would apply to these liquid solutions.

The form of N, timing, application method, and resulting weather conditions all play a role in achieving maximum N value. Often producers have few options to change the type of fertilizer product they use, but there are adjustments that can be made to timing and the application method. Utilize these products to bring the greatest value to your 2009 season.

For more information on fertilizer sources and management, visit www.fieldcrop.msu.edu

## MSU Nitrogen recommendations for wheat in 2009

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Evaluate wheat at green-up to determine damage over the winter and yield potential. Farmers can hedge on nitrogen amounts by using a split application; apply 40 lb N per acre now and then make a second application prior to stem elongation (Feekes stage 6) if the crop condition and yield potential justifies doing so.

Up to 40 lb N per acre can be applied to wheat with a herbicide spray using UAN 28%, which is generally more expensive than urea, but will save an extra trip across the field. Dilute the UAN with an equal portion of water and avoid using a surfactant in the spray mix. This will minimize leaf burn.

The total amount of N to apply should be based on the yield potential of the soil and crop condition. If the N price is 42 cents per pound and the projected wheat price is $4.60 per bushel, it will take 0.9 bushels of wheat to pay for each 10 pounds of N applied per acre. The first 40 to 60 lb N per acre in the spring application gives the biggest yield response. Four years of wheat nitrogen rate research at MSU has shown that topdressing 90 pounds of N only generated 1 to 3 bushels of yield increase for the extra 30 lbs of N per acre. With current prices and assuming 20-25 lb N per acre was applied in the fall, a formula for spring N application is (1.15 x Yield Potential) - 33. Applying this recommended amount of N will generally produce the best economic return if the yield potential is realized.

## Michigan State University recommendations for phosphorus and potassium

Pull out your soil tests and use the following information to assess phosphorus and potassium levels along with your 2009 crop plan to determine where fertilizer will benefit, and where you can save money on nutrients without sacrificing yield. The following charts will help to assess your current soil test levels, showing you where your test values are within the ranges, and help you decide how risky reducing fertilizer will be. For a complete listing, visit http://www.emdc.msue.msu.edu/mainsearch.cfm type E2904 in the inventory number box to search for Nutrient Recommendations for Field Crops in Michigan. Or click on the link for a complete PDF copy.

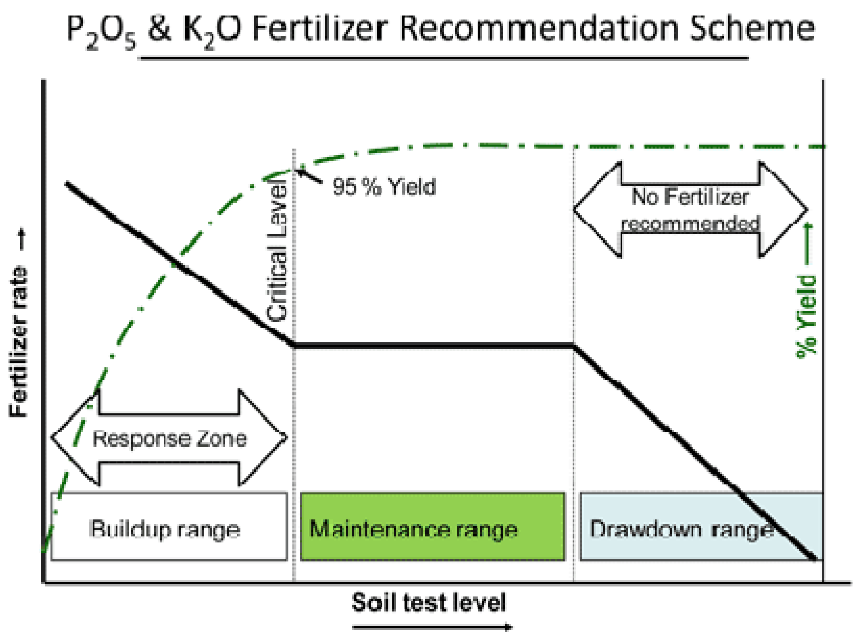
Phosphorus is always most efficient to band 2 X 2 at planting. The high price of potash may also encourage the use of banding to maximize the uptake efficiency of that nutrient as well. Maximum rates to band at 2 X 2 placement are in the following table.

| **Maximum fertilizer rates to band at 2 X 2 placement** | | | | |
|---|---|---|---|---|
| | **Lbs. N per acre** | **Lbs. $P_2O_5$ per acre** | **Lbs. $K_2O$ per acre** | **Max N + $K_20$[1]** |
| **Corn** | 40 | 100 | 100 | 100 (140) |
| **Dry Beans** | 40 | All recommended | 60 | 100 |
| **Soybeans** | - | 100 | 80 | 80 |
| **Sugarbeets** | 40 | 100 | 80 | 80 (120) |

[1]*Numbers in ( ) are for clayey soils.*

MSU's recommendations for $P_2O_5$ and $K_2O$ are based on the Buildup-Maintenance-Draw Down Model, shown below in Figure 1. The lower the level of available nutrients as indicated on a soil test, the greater the probability of a beneficial response to applied fertilizer. The critical level is the soil test level at which 95 percent of maximum yield is expected. This is usually near the maximum economic optimum return to fertilizer.

**Figure 1.**




For potassium, both the Cation Exchange Capacity (CEC) and the soil test value are taken into consideration to determine the critical value. See Chart 1a. When soil tests are below the critical level, yields will respond to applied nutrients, providing an economic return. Fertilizer recommendations are based on crop nutrient needs for the coming year and any additional nutrients required for building up the soil test values to above the critical level. Potash and phosphate recommendation guidelines are given in Charts 1a and 1b.

## Potassium ($K_2O$) Recommendation Guidelines

Compare your soil test levels to the following information:

| **Chart 1a: Potassium (K)** | **K Soil test value in ppm** (if reported in lbs./a K ÷2 = ppm) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Most Crops, Mineral Soils** | Soil test levels less than 80 ppm K | CEC =4 85-115 ppm | CEC=6 90-120 ppm | CEC=8 95-125 ppm | CEC=10 100-130 Ppm | CEC=12 105-135 ppm | Above the ppm in the chart to the left. |
| **Fertilizer considerations based on price of fertilizer, willingness to pay and/or acceptance of yield risk** | Responsive range for added potash.<br>1) Fertilize at soil test recommended rates which will include build up rates.<br>or<br>2) Fertilize at removal values (see table below) which | 1) Follow soil test recommendations.<br>or<br>2) Fertilize at or below removal rates, knowing that soil test levels will decline but yields should not be impacted until soil tests drop below this range. | | | | | 1) Apply no fertilizer; draw off soil bank. Re-soil test every 1-3 years to monitor balance in soil bank.<br>Or<br>2) if you must fertilize, apply at less than removal values see below: |

| | | | |
|---|---|---|---|
| | will maintain soil test levels. | | |

*see E-2904 for recommendations on organic soils.

**Chart 1b.**

# Phosphorus ($P_2O_5$) Recommendation Guidelines

Compare your soil test levels to the following information:

| **Chart 1b: Phosphorus (P)** | **P soil test value in ppm** (if reported in lbs./A P ÷2 = ppm) | | |
|---|---|---|---|
| **Alfalfa & Wheat** | 0 to 25 ppm | 25 ppm to 40 ppm | 40 ppm and above |
| **Corn, Soybeans & Sugar Beets** | 0 to 15 ppm | 15 ppm to 30 ppm | 30 ppm and above |
| **Dry Beans** | 0 to 15 ppm | 15 ppm to 40 ppm | 40 ppm and above |
| **Fertilizer considerations based on price of fertilizer, willingness to pay and/or acceptance of yield risk** | 1) Fertilize at soil test recommended rates which will include build rates. Or 2) Fertilize at removal values (see table below) which will maintain soil test levels. | 1) Follow soil test recommendations. or 2) Fertilize at or below removal rates, knowing that soil test levels will decline but yields should not be impacted until soil tests drop below this range. | 1) Apply no fertilizer; draw off soil bank. Re-soil test every 1-3 years to monitor balance in soil bank. Or 2) if you must fertilize, apply no more than removal values see below: |

Above this critical level is a plateau range called the maintenance range. In this range, fertilizer recommendations are based on crop removal rates that will achieve economic production and maintain the soil test without expecting test levels to rise or fall. Since this is based on crop removal values, the fertilizer recommendation will vary depending on the crop grown and the yield potential (see Chart 2).

If soil test values are in the draw down range, no fertilizer will be needed. In this range, it is possible, profitable, and prudent to utilize the nutrients stored in the soil from past fertilizer and or manure applications. Additional resources are available at www.fieldcrop.msu.edu . Follow the link for a complete PDF copy of the Nutrient Recommendations for Field Crops in Michigan, bulletin E2904.

**Chart 2**

| Removal rates of $K_2O$ and $P_2O_5$ at various yield potentials | | | |
|---|---|---|---|
| **Crop** | **Yield Potential** | **Estimated $P_2O_5$ crop removal** | **Estimated $K_2O$ crop removal** |
| | | Per acre, per year | Per acre, per yr. |
| Corn | 100 | 37 | 27 |
| per bushel | 125 | 46 | 34 |
| | 150 | 56 | 41 |
| | 200 | 74 | 54 |
| | | | |
| Alfalfa | 3 | 39 | 150 |
| per ton of dry hay equiv. | 5 | 65 | 250 |
| | 7 | 91 | 350 |
| | | | |
| Soybeans | 30 | 24 | 42 |
| per bu. | 40 | 32 | 56 |
| | 50 | 40 | 70 |
| | 60 | 48 | 84 |
| | | | |
| Dry Beans | 15 | 18 | 24 |
| per CWT | 20 | 24 | 32 |
| | 25 | 30 | 40 |
| | 30 | 36 | 48 |
| | | | |
| Sugar Beets | 20 | 26 | 66 |
| per ton | 25 | 33 | 83 |
| | 30 | 39 | 99 |
| | 35 | 46 | 116 |
| | | | |
| Wheat | 50 | 32 | 19 |
| per bu. | 70 | 44 | 26 |
| | 90 | 57 | 33 |

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