Variable-Rate Application of Fertilizer
by
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Variable-rate application of fertilizer is a common practice for crop production in many states. The technology was introduced in the 1970’s and 80’s in some parts of Montana but never was widely adopted. NRCS developed a conservation initiative in 2003 in north-central Montana to encourage producers to evaluate the adoption of this practice on their operations. Improved water quality in surface and ground water would result from adoption of this technology. Improvements in plant health would also occur because nutrients would be applied according to the plant needs across the entire field rather than the average of the field.

Five producers who participated in the conservation initiative were interviewed to determine costs and benefits associated with adoption of the variable-rate application of fertilizer. Producers also provided feedback on ways to improve adoption of the new technology. Information obtained from each producer is summarized by the producer. A summary will follow the producer information.

Producer 1 – Glacier County, Montana
1. Mean Annual Precipitation: 12 – 14 inches.
2. Soils are predominantly gravelly loam with loam and clay soils in some of the fields.
4. Variable-rate applied fertilizer for three years.

Before variable-rate fertilizer application:
1. Soil tested yearly:
   a. Applied 160-180 pounds 46-0-0 ($335 per ton for 46-0-0).
   b. Applied 50 pounds 11-52-0 when seeding ($335 per ton).
2. Fertilizer cost was $28.47 plus $8.38 = $36.85 per acre.
3. Protein for malt barley was near the 13.5 percent cutoff for acceptance by brewer.

With variable-rate fertilization application:
1. Producer hired a Technical Service Provider (TSP) to provide technical expertise for variable-rate application of fertilizer.
2. TSP obtained satellite imagery of growing crops a couple times a year to develop zones. The zones closely followed the existing soil map of the fields. The zones were soil tested based on the satellite imagery. Cost of satellite imagery was $11.00 per acre the first two years and $5.00 per acre the third year.
a. Applied 80 pounds 46-0-0 ($335 per ton).
b. Applied 90 pounds 20-20-10 ($329 per ton).
3. Fertilizer cost was $13.40 plus $14.80 = $28.20 per acre
4. Fertilizer application costs were $1.50 per acre higher
5. Year one had a five bushel higher yield. Years two and three had no yield change.
6. There was a major improvement in quality of the malting barley in terms of plumps, thins, and protein. Protein levels were around 12.5 percent. Gravel knobs produced 40 bushels per acre as compared to previous years when they produced little grain.

Change:
1. Fertilizer savings of $8.65 per acre.
2. Increased fertilizer application costs of $1.50 per acre.
3. Cost of satellite imagery of $11.00 per acre for the first two years and $5.00 the third year.
4. Five-bushel yield increase the first year, and no change the second and third year.

Producer 2 – Glacier County, Montana
1. Mean annual precipitation: 10 – 14 inches.
3. Dry land cropland spring wheat.
4. This is the first year of variable-rate application of fertilizer and the month of July was hot and dry which affected yields on all crops.

Before variable-rate fertilizer application:
1. Applied 70 pounds of fertilizer with the drill.

With variable-rate fertilization application:
1. Producer paid $3,600 for zone development by a TSP on 521 acres for a cost of $6.90 per acre.
2. The cost of variable-rate fertilization application was $4.00 per acre which was the same as before.
   a. Broadcast 104 pounds of 46-0-0 ($330 per ton).
   b. 70 pounds applied with the drill.
3. There was no change in the yield as compared to fields without the variable-rate application of fertilizer. Protein was 0.5 percent higher. In previous years there was a premium of $.02 per quarter percent increase in protein when the grain was sold.
4. The re-crop yield was 21-22 bushels per acre. Yields after chemical fallow were 29 and 33 bushels per acre depending on the variety. The one variety was susceptible to sawfly damage.
5. Purchased a used GPS guidance system that could be used in the tractor or combine for $6,700. The yield monitor on the GPS-guided combine gathered yield data that the TSP would use to print out a map showing yield variation for an additional charge of $1.00 per acre. The producer used their own software to print out the map.

Change:
1. Cost of zone development of $6.90 per acre.
2. Increased fertilizer cost of $17.16 per acre.
3. Protein increased 0.5 percent (25 bushels times $.04 per bushel = $1.00 per acre).
4. Cost of GPS guidance system ($6,700) which can be used for all farming operations.
5. No yield change which can be partially related to the hot weather in July.

Suggestions for program improvement:
1. Producer felt it was a worthwhile conservation initiative.
2. Increase the payment for zone development.
3. Reduce the payment for variable-rate fertilizer application.

Producer 3 – Glacier County, Montana
1. Mean annual precipitation: 12 – 14 inches.
2. Soils: clay loams and loams.
3. Dry land cropland spring wheat fallow rotation.
4. This is the second year of variable-rate application of fertilizer.

Before variable-rate fertilizer application:
1. Applied 116 – 120 pounds of 40-20-0 with the drills.
2. Average yield is 30 bushels.
3. Producer has GPS guidance system for equipment with yield monitors (cost of guidance system was $6,000).

With variable-rate fertilization application:
1. Producer hired a TSP to provide technical expertise for variable-rate application of fertilizer.
2. The TSP obtained satellite imagery of growing crops a couple times a year to develop zones.
3. Cost of zone development was $5 - $8 per acre.
4. Need a three-tank air seeder to variable-rate apply nitrogen. (One tank contains the seed, one tank contains nitrogen, and the third tank has the phosphorus fertilizer. Both the nitrogen and phosphorus were applied at a variable rate.)
5. Producer purchased a task controller for $1,500 to variable-rate apply the fertilizer.
6. The fertilizer is applied with the seed in a single shovel that applies both over the six-inch opening. This shovel is a No-Till Low Disturbance Six Inch. Fertilizer cost was $1 - $2 per acre more with the variable-rate application. The fertilizer on the variable-rate applied field cost the same as the conventionally applied fields.
7. In 2005, five-bushel increase in yield on 500 acres, protein was 0.5 – 0.7 percent higher with a $.20 per quarter percent increase in protein per bushel premium.
8. In 2006, one to two bushel increase in yield and there was no premium for protein. Average yields were in the high 30’s and low 40’s for his entire crop.
9. General comments - Producer felt it works great on hilly fields; very little nitrogen is applied on the hill tops. In the past the hills would burn up because of the high fertilizer rate and thin soils. They had the best stands on the hill tops they have ever had. Expects a two to four bushel increase in yield for variable-rate application of fertilizer in future years with average moisture, plans to use a soils map to develop zones in the future and will do variable-rate application of fertilizer on all their land that has hilly terrain.

Change:
1. Cost of zone development of $5 - $8 per acre.
2. Cost of $1,500 task controller.
3. Yield increase of five bushels in year one and one to two-bushel increase in the second year
4. Protein premium of $.20 per quarter percent increase per bushel for 30 bushels in the first
year and no premium in the second year, but this will vary each year.
5. Increased fertilizer cost of $1 - $2 per acre.
6. Expects a two to four-bushel increase in yield in future years.

Important considerations:
1. Develop three zones for variable application of fertilizer and do a good job of soil sampling
and be sure to calibrate the yield monitor before starting harvest to get good data.
2. Look at the fertilizer cost per acre that you are willing to spend and then variable-rate apply
the fertilizer.
3. 500 acres is a good number of acres to start learning the variable-rate application of the
fertilizer process.

Producer 4 – Toole County, Montana
1. Mean annual precipitation: 10 – 12 inches.
3. Dry land cropland.
4. Crop fallow cropping system with spring wheat after no-till fallow.

Before variable-rate fertilizer application:
1. Producer had fertilized for ten years.
2. In 2003, applied 177 pounds of 55-25-5-5 on re-crop acres and applied 140 pounds of
55-25-5-5 on fallow acres which cost $13.65 per acre.
3. In 2004, applied 110 pounds of 25-25-5-5 dry fertilizer for a cost of $12.50 per acre plus
$4.50 per acre for liquid fertilizer for a cost of $17.00 per acre.
   a. 2004 was a dry year and averaged 26.4 bushels per acre.
   b. Producer did not have a yield monitor on the combine.

With variable-rate fertilization application:
1. In 2006, zone development was $6.00 per acre by a TSP.
2. Soil tests were $30.00 per test.
3. Five zones were developed and designing the zones cost $235 or $.47 per acre.
4. Producer applied 73 pounds of 20-20-0 with the drill at a cost of $11.28 per acre; also applied
variable-rate liquid of 28-0-0 for a cost of $3.50 per acre application cost plus $14.82 for
fertilizer for a cost of $29.60 per acre.
   a. Zone application variable rate varied from 0 pounds to 100 pounds.
   b. Average yield was 40 bushels – was a good crop year.
5. Looking for a 20 percent increase in average yield in future years due to evened-out yield
across the field.
6. Producer spent more on fertilizer in 2006 because dry fertilizer prices increased 30 percent
and wanted to even up the yield across the field
7. Producer wants to use the yield maps obtained when harvesting the grain to develop the
fertilizer rates to variable-rate apply the fertilizer.
Change:
1. Areas where no nitrogen was applied produced better yields than in the past. In the past, the areas would have good straw, but not a good yield. The south-end of the field would be ten to 12 bushels less due to over-fertilizing.
2. The yield across the field evened out.
3. Producer spent $12.60 per acre more on fertilizer.

Important considerations:
1. Producer needs a GPS guidance system for combine for yield monitor.
2. Develop a realistic yield goal based on a yield within ten percent of the average yield.

Producer 5 – Teton County, Montana
1. Mean annual precipitation: 11 – 14 inches.
3. Dry land cropping system of winter wheat after chemical fallow.
4. This is the first year of variable-rate application of fertilizer. Received six inches of precipitation in June and received no moisture during the hot summer.

With variable-rate fertilization application:
1. Producer developed three zones.
2. It cost $6.00 per acre to get the satellite imagery to develop those zones; $50.00 per zone to design the zone; $150 per zone to install the zone.
3. It cost $4.00 per acre to apply the fertilizer which is $.50 per acre more than the uniform rate of fertilizer application.
4. The variable rate of fertilizer varied between 122 and 193 pounds per acre with an average of 154 pounds of 46-0-0 at a cost of $300 per ton. There were some problems with the spreading of the fertilizer.
   a. 80 pounds of 11-52-0 were applied through the drill.
   b. A 60-bushel yield goal was used at a rate of 2.6 pounds of nitrogen per bushel.
   c. The total volume of fertilizer applied on the field was about the same as the uniform rate of fertilizer application used in previous years.
5. The yields on hill tops seemed better.
6. The producer has custom harvesters and they do not have yield monitors.
7. Average yields were 65 bushels whether the field had fertilizer variable-rate applied or uniformly applied.
8. Producer does not plan on variable-rate applying fertilizer in the future.

Change:
1. Cost of zone mapping of $6.00 per acre.
2. Cost of design and installation of $300 for the zones.
3. $.50 per acre increased cost of variable-rate application of fertilizer.
Summary:

Five producers were interviewed about their experiences with the new technology of variable-rate application of fertilizer. Experiences and results of each producer were unique.

Some producers showed fertilizer savings while others had no savings in fertilizer cost. Some producers used a realistic yield goal to establish the quantity of fertilizer to apply to the field and then variable-rate applied the fertilizer. Others set a target fertilizer cost per acre and then variable-rate applied the fertilizer. Finally, others wanted the volume of nutrients to be the same for the variable-rate application field as other fields on the farm but have the fertilizer applied at a variable-rate.

Some producers experienced yield increases, while others had no yield change. The yield increases may have occurred in one year and not the next. Other producers had differences in protein levels.

Some summary conclusions were:

1. There was a learning curve involved for everyone trying the new technology. The quality of product provided by the TSP varied from good to bad. The entity doing the fertilizer application sometimes experienced problems getting the proper rate applied. In a few instances the fertilizer had to be applied twice to get the correct rate.
2. When producers applied the variable-rate fertilizer themselves they needed a three-tank system to keep the starter fertilizer application with phosphorus different than applying the nitrogen at a variable rate.
3. A GPS precision guidance system was required to apply the fertilizer for the different zones developed.
4. A GPS guidance system for the combine with a yield monitor is needed to see the results of the variable-rate application of fertilizer. The yield monitor results can then be used to refine the zones and determine additional areas for soil testing.

The NRCS conservation initiative in north-central Montana to encourage producers to evaluate the adoption of variable-rate application of fertilizer was a success. Producers in several counties in north-central Montana tried the new application method. Of the five producers interviewed, most planned to continue variable-rate application of fertilizer. The producers planned to continue to refine the zones and the amount of fertilizer applied. This will result in the best use of the fertilizer and the corresponding yields associated with the fertilizer application. In areas where excess fertilizer was applied, groundwater will be improved due to less leaching of nutrients.