# Lower Yakima Valley Groundwater Management Area Deep Soil Sampling Analysis of Fields Planted in Triticale/Corn Silage

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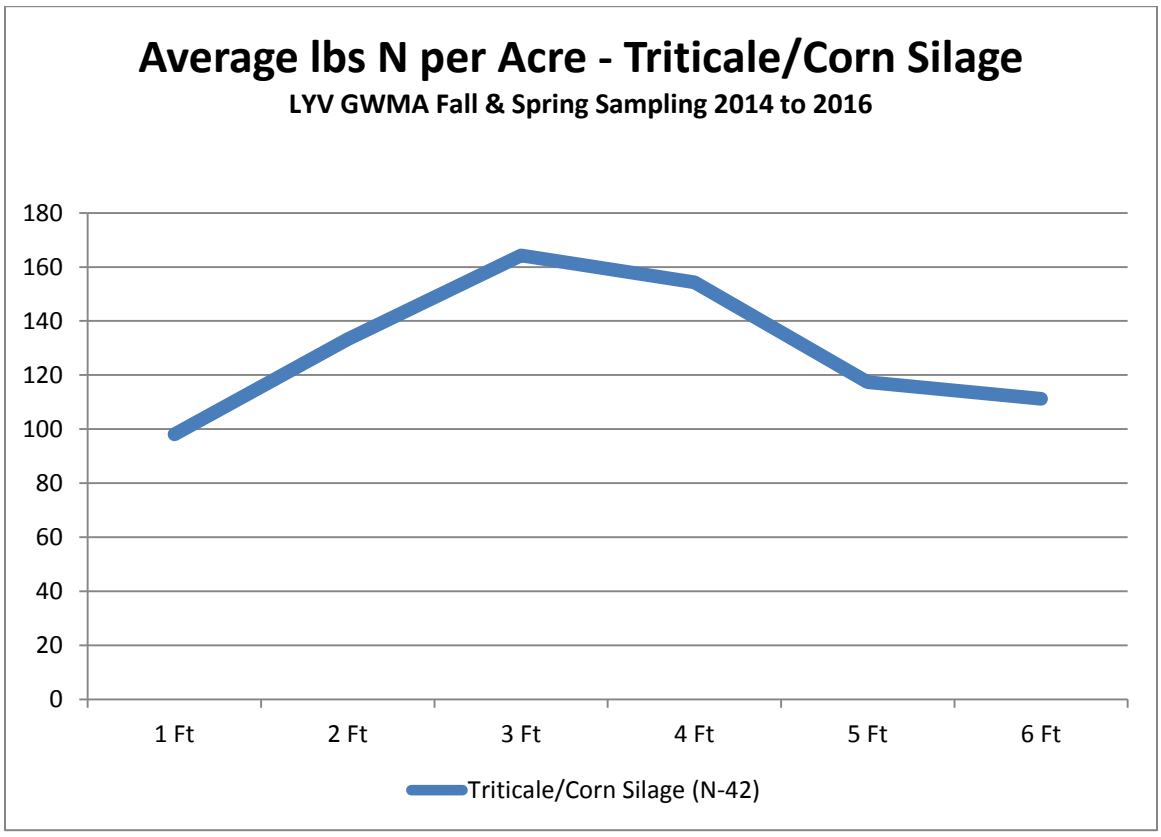
Between the fall of 2014 and the spring of 2016 the Lower Yakima Valley (LYV) Groundwater Management Area (GWMA) contracted with the South Yakima Conservation District and Landau Associates to perform four rounds of deep soil sampling (DSS) on agricultural land in the GWMA target area. All fields were voluntarily submitted and anonymously recorded. 24% of the fields (42 out of 175) were double cropped in Triticale/Corn Silage (40) or Triticale/Sudan Grass (2). This is the largest number for any crop in the DSS and lends itself to a more detailed study.

## Overview of the Data

Below is a graph that depicts the nitrate levels in lbs of nitrate ($NO_3$) per acre at depths by one foot increments.

Graph 1.



The average field was 55.5 acres. Soil testing was done on all fields. Testing was done twice a year for 27 of the fields (64%) and annually for 15 of the fields (36%). There was rill irrigation on one field, rill & sprinkler irrigation on two fields and sprinkler irrigation only on thirty nine fields.

Liquid manure was applied to 31 of the fields (74%), solid manure to 5 of the fields (12%), commercial fertilizer to 26 (of the fields 62%) and bio-solids to 1 of the fields (2%). More than one type of fertilizer was used on 22 of the fields (52%).

The capacity of the most limiting layer to transmit water (Ksat) classifications were "very low to moderately low" on 4 of fields (10%), "moderately high to high" on 34 of fields (81%), and "high to very high" on 4 of fields (9%).

There was early refusal of the soil drilling equipment on one field at 2 feet, four more at 3 feet, one more at 4 feet and six more at 5 feet. Early refusal was more likely in the soils classified as very low to moderately low leaching.

Average root depth was 2.87 feet and the median was 2.85. The range for root depths was 1 ft to 5.8 ft.

## Data Analysis for Triticale/Corn Silage

Table 1. Nitrate in lbs per Acre for Triticale/Corn Silage

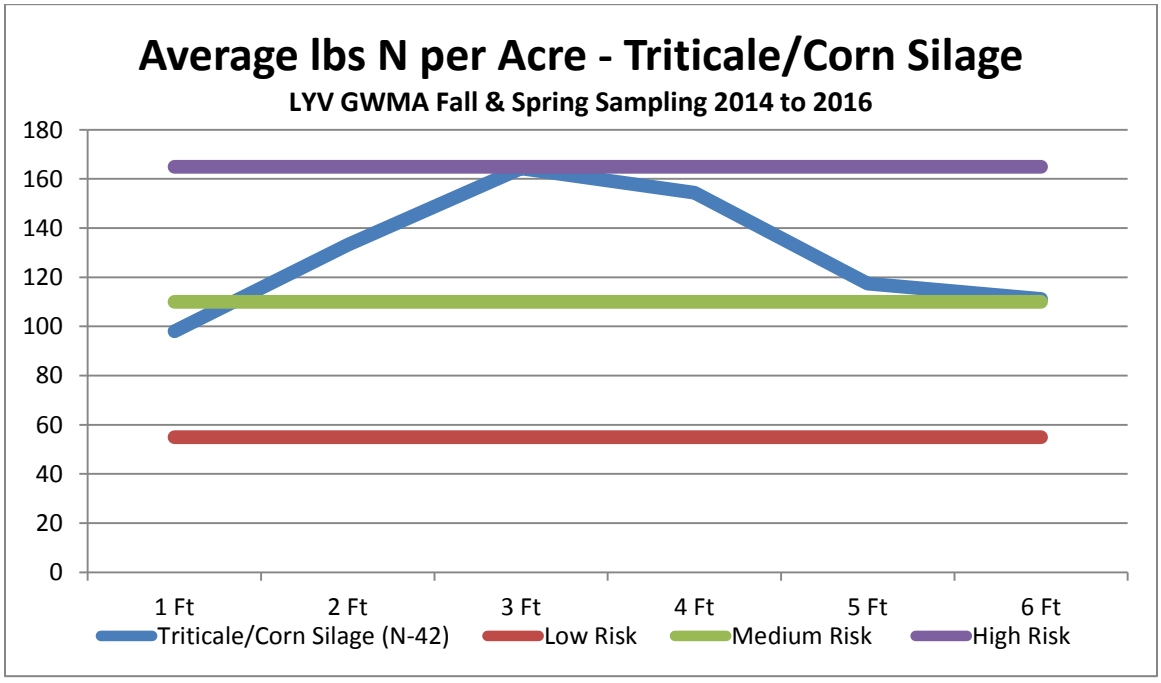
| | 1 FT | 2Ft | 3 Ft | 4 Ft | 5 Ft | 6 Ft | Total | $NH_3$ | Organic |
|---|---|---|---|---|---|---|---|---|---|
| Average (lbs/acre) | 98.07 | 133.24 | 164.3 | 154.36 | 117.43 | 111.2 | 668.5 | 29 | 2.25 |
| Median (lbs/acre) | 57 | 60 | 87 | 89 | 60 | 66 | 356.5 | 24 | 2.18 |
| Range (lbs/acre) | 4 to 467 | 3 to 986 | 3 to 892 | 3 to 726 | 6 to 576 | 4 to 565 | 17 to 3754 | 9 to 108 | 0.95 to 3.94 |
| Early Refusal (ft) | 0 | 1 | 5 | 6 | 12 | 12 | | | |

The median is much less than the average at all depths. The data has a positive skew.

The sampling shows that there are high nitrate levels at depths where the crops no longer take up the nitrate for plant use. In other words, there is significant leaching to the aquifer from fields planted in triticale/corn silage.

One way to look at the data is to determine how many fields have nitrate levels above the risk levels that were defined by Ecology (2017) for the CAFO General Permits. According to that document there is low risk when nitrate levels at two feet are < 55 lbs per acre, medium risk when levels are 55lbs per acre to 110 lbs per acre, high risk when levels are 110 lbs per acre to 165 lbs per acre and very high risk when levels are > 165 lbs per acre. The average level of nitrate in this study was in the high risk range for all levels except one foot.

Graph 2.




**Analysis at the Two Foot Level**

Another way to analyze the material is to look at the two foot level where most nutrient management plan decision making is done for Eastern Washington. Numbers in the table below were sorted by size for the two foot level. There were 19 samples in the low risk category (< 55 lbs/acre), 14 samples in the medium risk category (55lbs/acre to 110 lbs/acre), none in the high risk category (110 lbs/acre to 165 lbs/acre) and 9 samples in the very high risk category (>165lbs/acre).

Table 2.

| Field ID # | 1 FT lbs/ac | 2Ft lbs/ac | 3 Ft lbs/ac | 4 Ft lbs/ac | 5 Ft lbs/ac | 6 Ft lbs/ac | Total lbs/ac | Ammonia lbs/ac | Organic Matter |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| Very High Risk | | N = 9 (21%) | | | | | | | |
| 2058 | 119 | 986 | 892 | 694 | 407 | 287 | 3385 | 16 | 1.92% |
| 3094 | 467 | 644 | 776 | 726 | 576 | 565 | 3754 | 50 | 2.85% |
| 3108 | 311 | 465 | 612 | 684 | 247 | 264 | 2583 | 27 | 2.66% |
| 3106 | 316 | 445 | 465 | 248 | 256 | 222 | 1952 | 15 | 0.95% |
| 3097 | 336 | 363 | 335 | 263 | 113 | 64 | 1474 | 28 | 2.18% |
| 2063 | 227 | 337 | 424 | 528 | | | 1516 | 24 | 3.94% |
| 2065 | 213 | 304 | | | | | 517 | 15 | 2.59% |
| 3121 | 275 | 193 | 162 | 137 | 202 | 272 | 1241 | 32 | 2.91% |
| 2066 | 44 | 182 | 193 | | | | 419 | 24 | 3.23% |
| | | | | | | | | | |
| Medium Risk | | N = 14 (33%) | | | | | | | |
| 2037 | 50 | 106 | 226 | 183 | 149 | 72 | 786 | 93 | 1.9% |
| 3110 | 93 | 100 | 125 | 154 | 283 | 413 | 1168 | 34 | 2.19% |
| 2067 | 19 | 97 | 197 | 115 | 40 | 27 | 495 | 18 | 1.56% |
| 3115 | 82 | 90 | 149 | 111 | 192 | 195 | 819 | 14 | 1.67% |
| 3095 | 60 | 90 | 140 | 178 | | | 468 | 17 | 1.92% |
| 2078 | 49 | 89 | 86 | 156 | 172 | 111 | 663 | 27 | 2.62% |
| 2046 | 36 | 88 | 95 | 70 | 65 | 72 | 426 | 33 | 2.67% |
| 4167 | 97 | 81 | 88 | 13 | | | 279 | 68 | 1.39% |
| 1004 | 177 | 79 | 63 | 69 | 42 | 50 | 480 | 16 | 2.06% |
| 3112 | 39 | 73 | 87 | 95 | 47 | 38 | 379 | 22 | 1.87% |
| 2079 | 9 | 66 | 127 | 173 | 98 | 108 | 581 | 17 | 2.62% |
| 3109 | 82 | 60 | 223 | 238 | 56 | 100 | 759 | 12 | 1.48% |
| 2053 | 84 | 58 | | | | | 142 | 11 | 1.59% |
| 2035 | 55 | 56 | 56 | 103 | 110 | 93 | 473 | 108 | 3.04% |
| | | | | | | | | | |
| Low Risk | | N = 19 (45%) | | | | | | | |
| 2081 | 75 | 48 | 40 | 42 | 32 | 24 | 261 | 35 | 2.45% |
| 2036 | 90 | 47 | 31 | 23 | 12 | 6 | 209 | 65 | 2.37% |
| 3111 | 35 | 45 | | | | | 80 | 24 | 1.59% |
| 2068 | 7 | 35 | 137 | 115 | | | 294 | 13 | 1.71% |
| 3086 | 139 | 30 | 33 | 56 | 47 | 29 | 334 | 14 | 1.76% |
| 2070 | 37 | 26 | 63 | 83 | 51 | 38 | 298 | 9 | 0.98% |
| 2064 | 52 | 26 | 43 | 26 | | | 147 | 19 | 3.21% |
| 2040 | 41 | 25 | 13 | 36 | 88 | 68 | 271 | 26 | 3.09% |
| 2082 | 41 | 22 | 55 | 70 | 58 | 74 | 320 | 25 | 3.36% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2077 | 26 | 22 | 26 | 25 | 35 | 41 | 175 | 16 | 1.81% |
| 3122 | 101 | 20 | 14 | 3 | 16 | 4 | 158 | 23 | 2.07% |
| 4159 | 34 | 16 | 36 | 27 | 7 | 9 | 129 | 40 | 2.41% |
| 2080 | 15 | 15 | 27 | 44 | | | 101 | 17 | 2.63% |
| 2050 | 18 | 9 | 21 | 43 | 61 | 51 | 203 | 25 | 2.95% |
| 4161 | 66 | 9 | 6 | 5 | 8 | 8 | 102 | 39 | 2.59% |
| 3096 | 27 | 8 | 10 | 17 | 47 | 19 | 128 | 44 | 2.06% |
| 4158 | 12 | 5 | | | | | 17 | 38 | 2.18% |
| 2041 | 4 | 3 | 3 | 4 | 6 | 12 | 32 | 9 | 1.46% |
| 2052 | 59 | | | | | | 59 | 16 | 2.16% |

These nitrate values do not conform to a normal curve but statistical analyses can be done by plotting log values for the nitrate levels. This normalizes the data and tells us that 95% of the nitrate levels at 2 feet for the fields in this study will lie between 4.2 lbs per acre and 815.2 lbs per acre. This is a very large range. There are 2 out of 41 values in the study that lie outside the 95 percentile range. They are 3 lbs per acre at the low end and 986 lbs per acre at the high end.

Analysis of Irrigation Practices found that most samples (89% to 100%) used sprinkler. There is a small trend for lower risk fields to use rill irrigation but the numbers are not large enough to prove statistical significance. :

Table 3. Irrigation Practices and Risk Levels for Triticale/Corn Silage

| | Low Risk | Medium/High Risk | Very High Risk | All Samples |
|---|---|---|---|---|
| | | | | |
| Rill | 2 (11%) | 1 (7%) | 0 (0%) | 3 (7%) |
| Sprinkler | 17 (89%) | 13 (93%) | 9 (100%) | 39 (93%) |
| Drip | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |
| | | | | |

There were no dose dependent relationships for ammonia or organic matter and risk

Table 4. Average Ammonia & Organic Matter Levels for Triticale/Corn Silage

| | Low Risk | Medium/High Risk | Very High Risk | All Samples |
|---|---|---|---|---|
| | | | | |
| Ammonia | 26.16 | 35.00 | 25.67 | 28.27 |
| | | | | |
| Organic Matter | 2.25 | 2.04 | 2.58 | 2.32 |

Note: Field #2035 in the Medium Risk category had an unusually high ammonia level of 108 #/acre

There were no clear trends regarding crop yields and risk categories:

Table 5. Crop Yield for Triticale & Corn Silage in Different Risk Levels

| | Low Risk | Medium Risk | Very High | All Samples |
|---|---|---|---|---|
| Average of Most Recent Crop Yields for Triticale in Tons | 8.14 T | 8 T | 8.22 T | 8.11 T |
| Average of Most Recent Crop Yields for Corn Silage in Tons | 29.39 T | 31.25 T | 30.22 T | 30.15 T |

There were no clear trends regarding impact of fertilizer type for these crops:

Table 6. Percentage of Fields that Received Major Types of Fertilizer for Triticale/Corn

| | Low Risk | Medium Risk | Very High Risk | All Samples |
|---|---|---|---|---|
| Liquid Manure | 15 (79%) | 10 (71%) | 6 (86%) | 31 (74%) |
| Solid Manure | 3 (16%) | 1 (7%) | 1 (14%) | 5 (12%) |
| Commercial Fertilizer | 12 (63%) | 10 (71%) | 4 (57%) | 26(62%) |
| Biosolids | 0 (0%) | 0 (0%) | 1 (14%) | 1(2%) |
| Unknown | 0 (0%) | 1 (7%) | 0 (0%) | 1 (2%) |
| More Than One Type | 10 (53%) | 8 (57%) | 4 (44%) | 22 (52%) |

There were no clear trends regarding soil type and leaching potential for these crops:

Table 7. Soil Categories and Risk Levels for Triticale/Corn Silage

| | Low Risk | Medium Risk | Very High Risk | All Samples |
|---|---|---|---|---|
| Low to Moderately Low | 2 (11%0 | 1 (7%) | 1 (11%) | 4 (10%) |
| Moderate to High Ksat | 14 (74%) | 13 (93%) | 7 (78%) | 34 (81%) |
| High to very High Ksat | 3 (16%) | 0 (0%) | 1 (11%) | 4 (10%) |

The major conclusion from analysis of data at the two foot level is that over half of the fields in this study are at medium to very high risk for leaching to the groundwater.

## Analysis Based on Median Levels at One Foot Intervals

Another way to analyze the data is to look at median levels of nitrate in lbs per acre at each level of testing. Half of all fields in a data set are above the median level and half are below the median level. The data in this study is skewed positively, meaning that median values are lower than average values. In this study half of nitrate levels were above:

a. 57 lbs per acre at one foot

b. 60 lbs per acre at two feet

c. 87 lbs per acre at three feet

d. 89lbs per acre at four feet

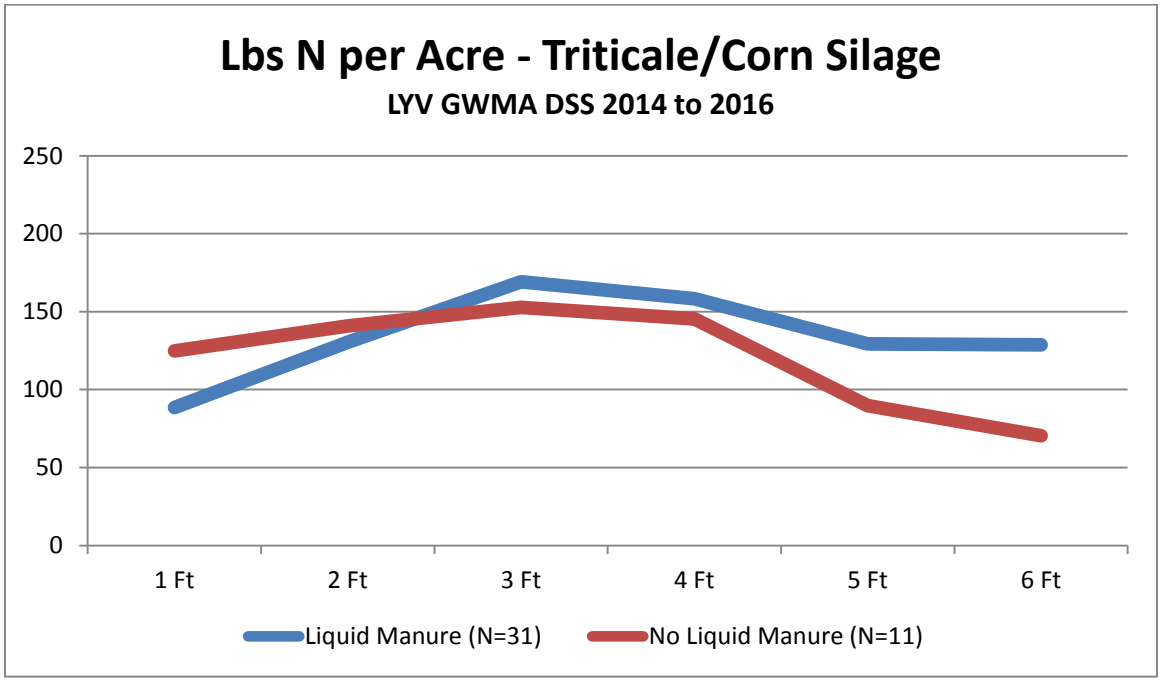
e. 60#lbs per at five feet

f. 66 lbs per acre at six feet.

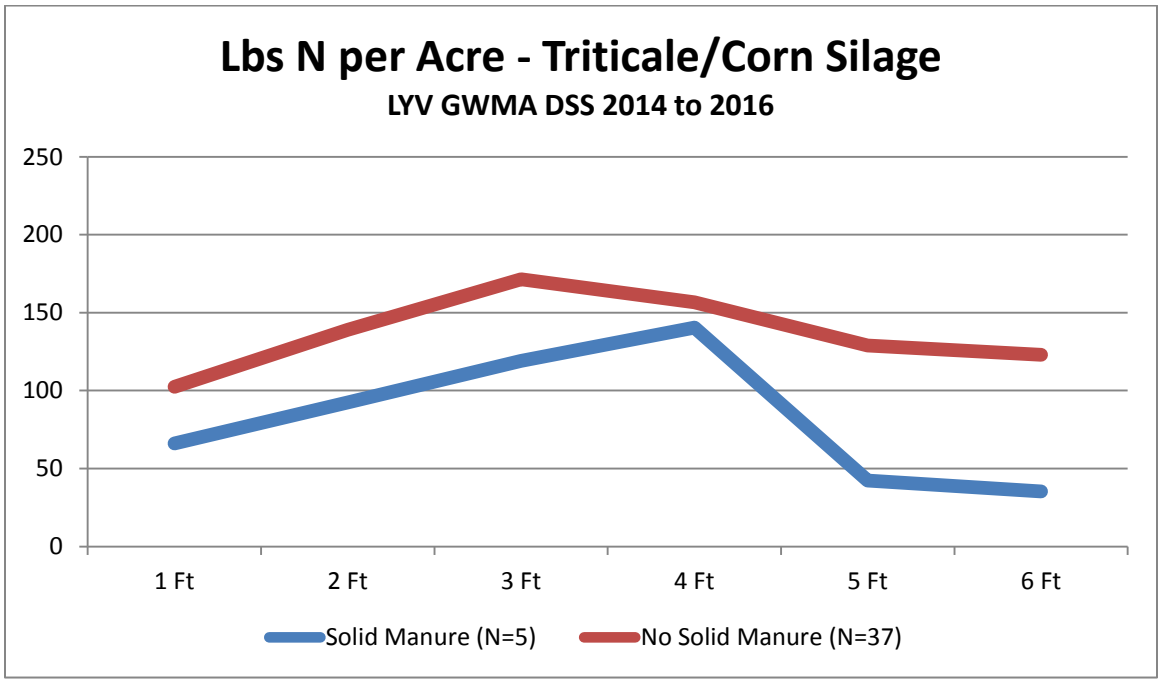
## Types of Fertilizers

Analysis of the DSS as a whole indicates that nitrate levels are higher when liquid manure is applied to the fields. Application of solid manure, on the other hand, is associated with lower nitrate levels. The graphs below describe nitrate levels for triticale/corn silage fields based on yes or no for application of each major class of fertilizer. 52% of the fields received more than one type of fertilizer and this practice was associated with a reduction in nitrate levels.

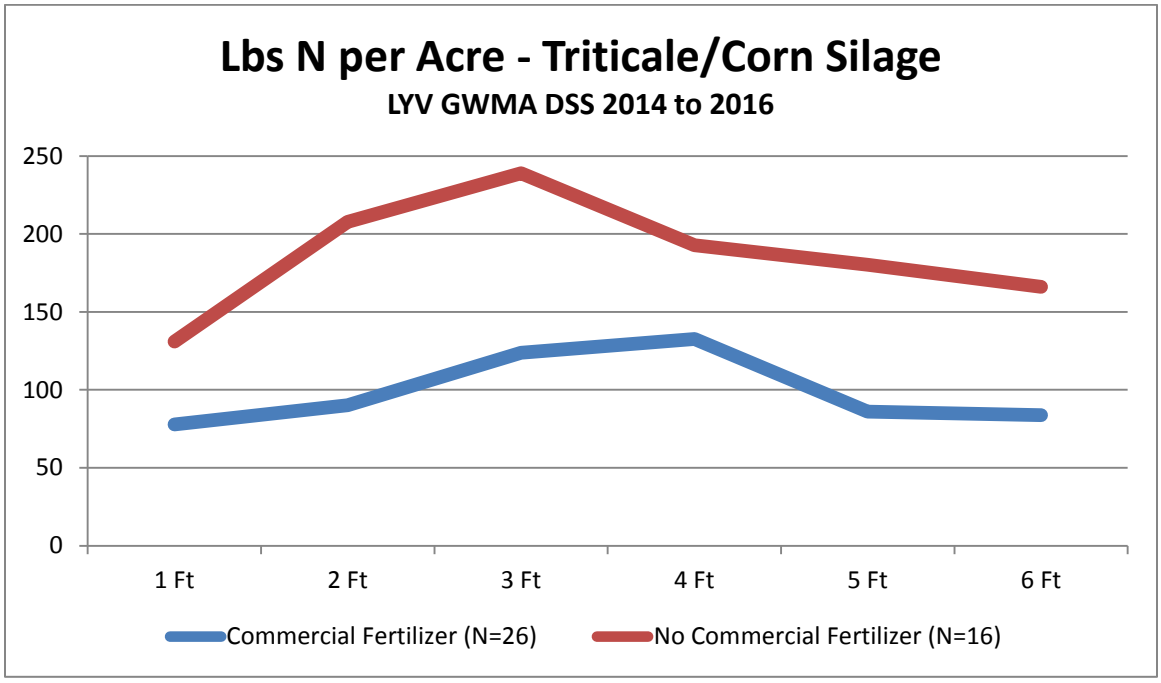
Graph 3. Fields that Received Liquid Manure and Those That Did Not



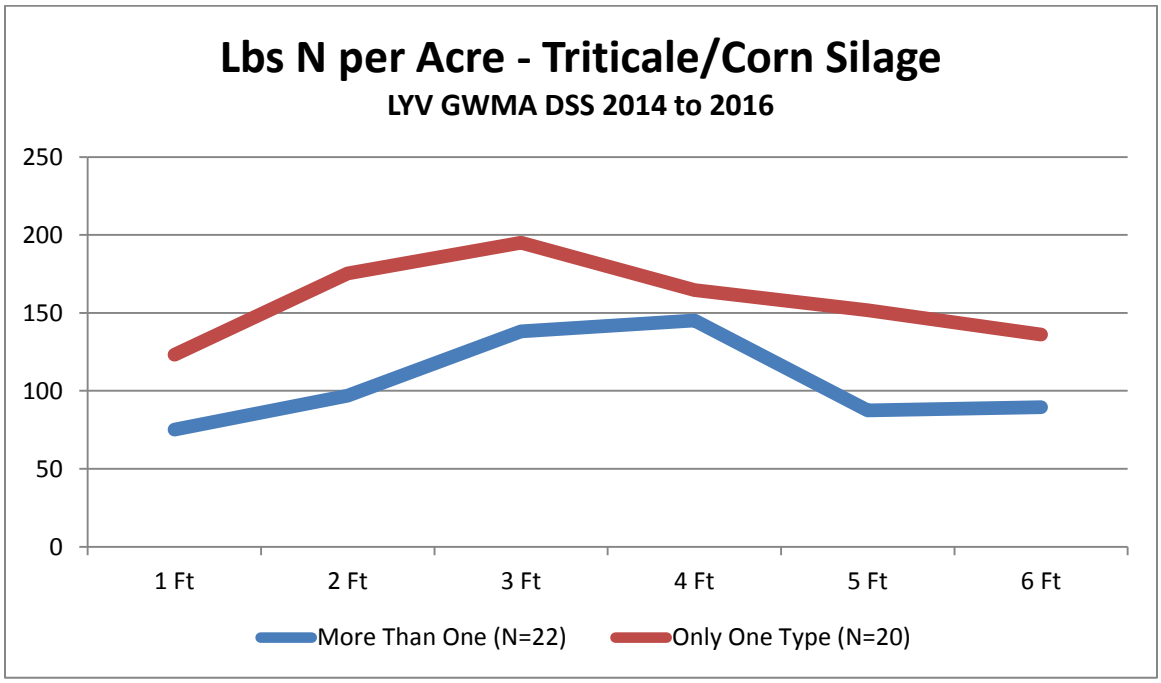

Graph 4. Fields that Received Solid Manure and Those That Did Not



Graph 5. Fields That Received Commercial Fertilizer and Those That Did Not




Graph 6. Fields That Received More Than One Type of Fertilizer or Did Not

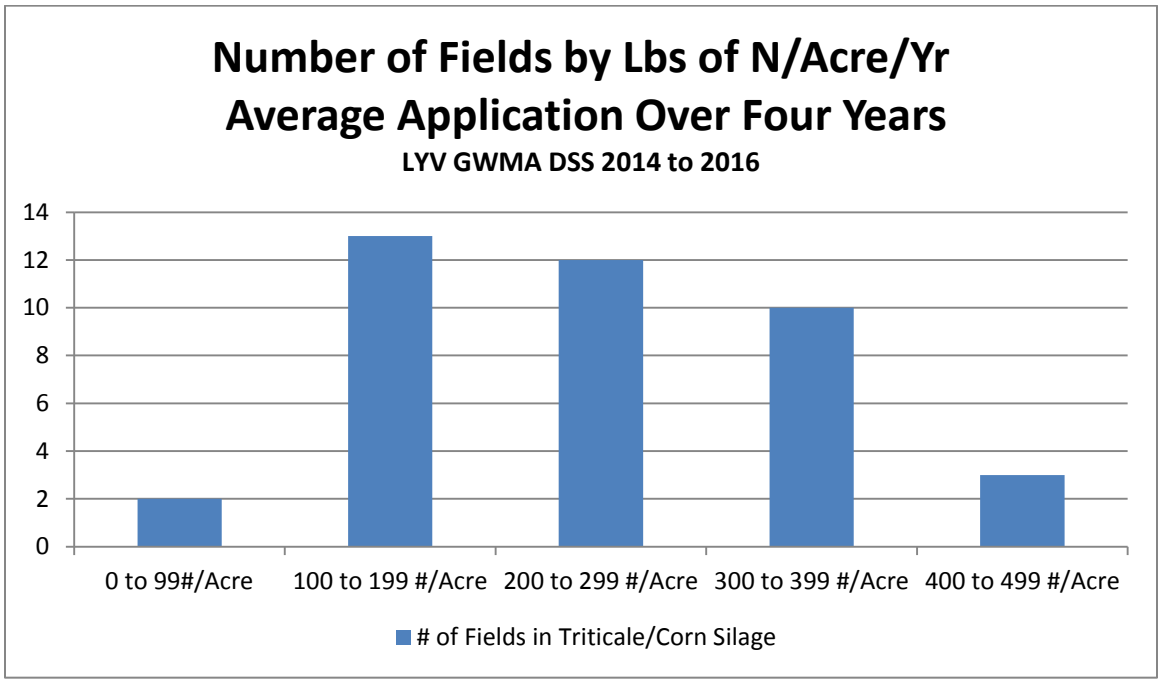



Could this indicate that farmers who apply more than one type are more thoughtful about fertilizer applications?

## Amount of Fertilizer

DSS surveys asked farmers how much nitrogen they applied in lbs N per acre to the sampled fields. Average application over four years was calculated for each field and the number of fields with application of 0 to 99lbs, 100 to 199 lbs, 200 to 299 lbs, 300 to 399 lbs and 400 to 499 lbs was counted.

Graph 7. Range of Fertilizer Application Rates to Triticale/Corn Silage Fields in DSS




According to the WSDA Nitrogen Loading Assessment (2017) and the recommendations of members of the GWMA Irrigated Ag Work Group the average uptake of nitrogen for corn silage is 270 #/acre. The uptake by triticale ranges from a low of 190 lbs per acre to a high of 210 lbs per acre. This indicates that most farmers in the DSS apply less than the recommended amounts of nitrogen to triticale/corn silage fields.

Some fields received high amounts of nitrogen fertilizer in single years. For example, Field # 2065 received 575lbs of N per acre in 2013; Fields # 2066 received 500 lbs of N per acre in 2012; Field # 2046 received 500 lbs of N per acre in three out of four years.

There is a clear upward trend in nitrogen application related to level of risk: On average fields in the low risk level received 211 lbs N per acre; those in the medium to high level received 250 lbs N per acre and those in the very high level received 258 lbs per acre.

Table 8. Average Nitrogen Application at Different Risk Levels

| | Low Risk | Medium/High Risk | Very High Risk | All Samples |
|---|---|---|---|---|
| | | | | |
| Average N Application in lbs per Acre | 211.45 | 249.92 | 258.25 | 237.06 |
| | | | | |
| Range of Average N Applications in lbs per Acre | 31.25 – 379.75 | 105 to 436 | 170 to 391.25 | 31.25 – 436 |
| | | | | |

Relationships can be examined by looking at the ratio of Total Nitrogen to Average Applied Nitrogen. Calculated Total Nitrogen is the sum of measurements at all six foot levels. Therefore those samples with early refusal were deleted from this analysis. The average ratios of Total Nitrogen to average Applied Nitrogen - were:

Very High Risk: 11.82 (Range = 7.44 to 20.42)

Medium to High Risk: 3.22 (Range = 1.10 to 7.23)

Low Risk: 1.52 (Range = 0.29 to 6.50)

## References

WA State Dept. of Agriculture (2017*) Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area*. Available in draft form only.

WA State Dept. of Ecology (2017) *Concentrated Animal Feeding Operation General National Pollutant Discharge Elimination System and State Waste Discharge General Permit.* Available at http://www.ecy.wa.gov/programs/wq/permits/cafo/docs/01182017CombinedPermit.pdf

WA State Dept. of Ecology (2017) *Concentrated Animal Feeding Operation State Waste Discharge General Permit.* Available at http://www.ecy.wa.gov/programs/wq/permits/cafo/docs/01182017StatePermit.pdf

## Errata

Towards the end of this analysis it was noted that two of the fields were planted in Sudan grass as well as the Triticale/Corn Silage combination. This could impact the data. The fields planted in Sudan grass were # 2046 and # 3096.