## *NORTH CAROLINA INTERAGENCY NUTRIENT MANAGEMENT COMMITTEE*

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United States Department of Agriculture - Natural Resources Conservation Service

# Date: July 31, 2014
# INMC Fact Sheet: Update of NC Realistic Yield Expectations Database Information for Corn

**Background**

Beginning in 2013, the NC Interagency Nutrient Management Committee (INMC) coordinated an effort to utilize the most current research data available to update soil-specific Realistic Yield Expectations (RYEs) and recommended nitrogen application rates for corn. The RYE database is the foundation for nitrogen rate recommendations supported by NCSU Department of Soil Science guidelines, including NCDA Soil Test recommendations and the NRCS 590 Nutrient Management conservation practice standard. The previous RYE database for corn was developed over 20 years ago, and did not account for corn hybrid genetics and management improvements that have resulted in increased yields across the United States. To ensure the RYE database for corn is current, committee NC State University faculty reviewed yield data from 80 corn nitrogen rate trials completed over from 2001-2011 across North Carolina. Over a series of meetings, the INMC discussed the NCSU data and formed consensus on updates to the NC RYE database for corn.

Attached to this Fact Sheet is "Nitrogen Rates for Corn", developed by committee NCSU Department of Soil Science faculty. The paper provides a detailed description of the update project, and includes the field experiment data utilized in the review.

"Nitrogen Rates for Corn" serves as the science reference basis for the 2014 NC corn RYE database and Nitrogen factor updates.

Recent INMC minutes on the NC Nutrient Management website serve as the reference to describe committee discussions and project decision making based on the NCSU analyzed data.

The corn RYE database has been updated on the Nutrient Management in NC website (http://nutrients.soil.ncsu.edu/yields/) to reflect the 'best science available' conclusions of the INMC.

**Rate Trials Description Points**

- 80 total corn N rate trials were reviewed. However, 34 irrigated experiments were deleted from the data analysis, as an underlying assumption of the RYE database is 'normal' rainfall and no irrigation needed to produce the RYE. ("Irrigated" corn yields may be integrated into nutrient management plans through collection of sufficient on-farm yield data.)

- 46 field experiments were included in the analysis, representing 16 distinct NC Soil Management Groups (SMGs).

- 10 of the included SMGs were in the Coastal Plain, with 3 in the Piedmont, and 3 in the Mountains. This resulted in 37 field experiment data points for the Coastal Plain SMGs, 4 field experiment data points for the Piedmont SMGs, and 5 field experiment data points for the Mountain SMGs. 3 of the 5 field experiments in the Mountains were 'Flood Plain' soils, characteristically distinct soils from the other field experiment locations.

- Yield equations were developed for each of the 46 analyzed experiments, concluding that the linear-plateau N response model provided the best way to determine optimum N rates and N factors (the per yield unit factor multiplied by the RYE to calculate the overall N rate).

- "New" optimum yields, N rates, and N factors were compiled from analyzed field experiment data for each of the 16 distinct SMGs, and then weighted averages of each regional (Coastal Plain, Piedmont, Mountains) set of SMGs were calculated and compared against previous SMG RYE yield and N rates.

**Update results as determined by data analysis (more fully elaborated on in "Nitrogen Rates for Corn" and INMC minutes):**

- The field experiment data (37 data points for 10 distinct SMGs) for the Coastal Plain SMGs showed a mean increase of 17% over 20+ year old 'current' RYE database yields.

- The field experiment data (4 data points for 3 distinct SMGs) for the Piedmonts SMGs showed a mean increase of 22% over 20+ year old 'current' RYE database yields.

- The field experiment data for the non 'flood plain' Mountain SMGs (2 data points for 2 distinct SMGs) showed a mean increase of 7% over 20+ year old 'current' RYE database yields.

- The field experiment data for the distinct flood plain Mountain SMG 205 (3 data points for SMG 205) showed an increase of 61% over 20+ year old 'current' RYE database yields.

- The field experiment data for all SMGs showed that optimum N rates (lbs./ac.) were very similar to the 'current' RYE-based N rates for Coastal Plain and Piedmont SMGs. Mountain SMGs showed a lower per N rate based on a limited number of field data experiments.

- The field experiment data showed corn nitrogen requirements were the same for conventional and long term conservation tillage.

**Conclusions:**

- Based on the analyzed data results as the best available science to update RYE database information for corn, the INMC concluded a RYE increase of **20%** was appropriate for ALL NC SMGs **except** Mountain SMG 205 (Flood Plain soil SMG). Due to the extraordinary corn production conditions the data showed in SMG 205, the INMC determined a RYE increase of 60% was appropriate for that SMG.

- The overall 20% yield increase for all NC SMGs (except SMG 205) is consistent with national yield trends of 1% increase per year since the previous NC RYE database yields were developed 20+ years ago.

- Because the analyzed field data N rates (based on the linear plateau response method) for the 'new' yields were shown to be very similar to current RYE-based N rates in the Coastal Plain and Mountains, and taking into account the practicality of substantially adjusting N rates in the mountains based on few trials, the INMC determined the overall SMG N rates should remain the same for ALL NC SMGs. The NCSU field experiment data analysis showed NC is growing more corn per acre with a lesser amount of N applied per bushel of average yield.

- Based on the INMC conclusions, the recommended nitrogen application rates for corn were not changed from the previous RYE database. Other than SMG 205, corn yields have increased by 20%, and N factors have been adjusted downward to produce same overall N rate as in the previous RYE database. In SMG 205, yield has been set to 250 bu/ac, and the N factor was adjusted down to result in the same N rate as in the previous RYE database.

**Nitrogen Rates for Corn**

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October 31, 2013

The Interagency Nutrient Management Group (INMC) recognized that the realistic yield expectation (RYE) data base was developed over 20 years ago. Due to progress in corn hybrid development, yields have been increasing across the United States and the world. To ensure that the RYE data base and nitrogen (N) recommendations are current, NC State University faculty (Crouse, Smyth, and Osmond) reviewed 80 N rate trials on corn from a 10-year period (2001-2011).

Experiments were randomized complete block designs with generally 4 replications. Often 4 to 6 N rates were tested but sometimes other factors such as spacing, fertilizer types, timing and placement were also considered. Irrigated experiments were deleted as the RYE data base assumes rainfed conditions. Thus a total of 46 experiments were included in the analysis below. The experiments represent 16 Soil Management Groups (SMGs): 10 in the Coastal Plain and three each in the Piedmont and Mountain. Locations are shown below (Figure 1).

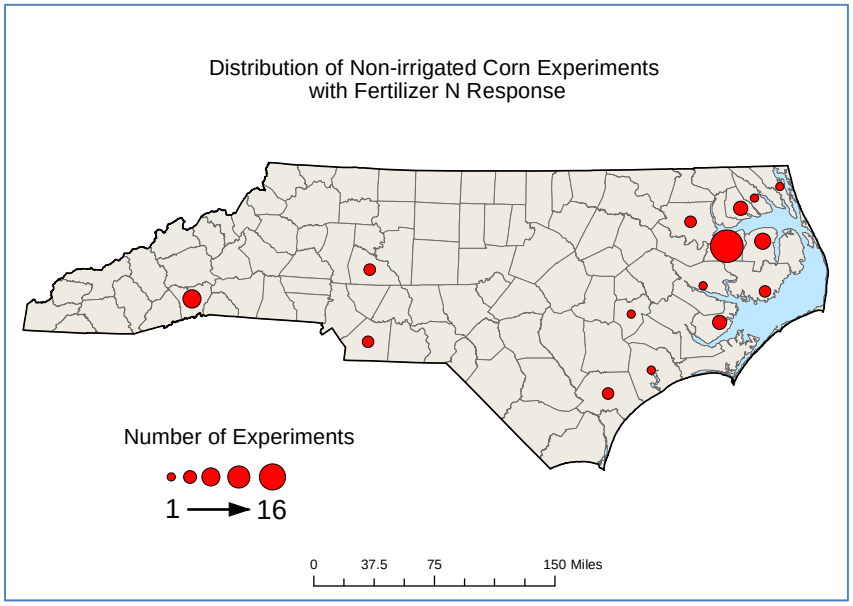

Figure 1. Location and number of corn, nitrogen rate experiments.

Some experiments had no yield response, generally due to drought conditions. These experiments were excluded from further analysis. Yield equations were developed for each experiment and it was determined that the linear-plateau response model provided the best fit. Examples of the technique are shown in Figure 2.

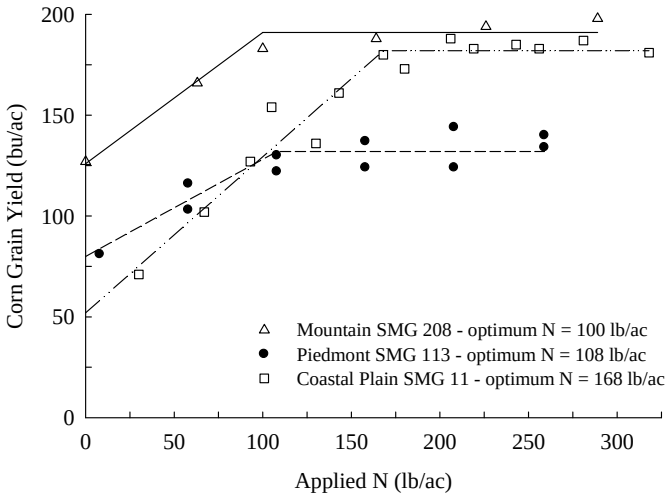


Figure 2. Linear-plateau response model for a Coastal Plain, Piedmont, and Mountain soil

Table 1 lists the Soil Management Group descriptions and mean linear-plateau N response parameters for these experiments.

Table 1. Soil Management Group (SMG) descriptions and mean linear-plateau N response parameters.

| SMG | Description | Trials | Y Intercept | Slope |
|---|---|---|---|---|
| | | | bu/ac | bu/lb N |
| | Coastal Plain | | | |
| 2 | 16-51" organic layer over sands, vpd[#] | 3 | 94 | 0.46 |
| 3 | 16-51" organic layer over silts, loams, vpd | 1 | 117 | 0.63 |
| 6 | Min-org histic or umbric, fine or silty, vpd | 8 | 76 | 0.38 |
| 7 | Min.-org. histic or umbric, loamy, vpd | 13 | 84 | 0.48 |
| 10 | Mineral, silty, pd | 4 | 81 | 0.48 |
| 11 | Mineral, fine, pd | 1 | 52 | 0.78 |
| 12 | Mineral, fine loamy & coarse loamy, pd | 3 | 91 | 0.51 |
| 20 | Mineral, fine loamy & coarse loamy, mwd | 1 | 84 | 0.69 |
| 25 | Mineral, fine loamy & coarse loamy, wd | 2 | 85 | 0.28 |
| 27 | Arenic, 20-40" to Bt, loamy, wd to ewd | 1 | 50 | 0.39 |
| | Piedmont | | | |
| 109 | Rhodic, fine, wd | 1 | 25 | 1.14 |
| 111 | Felsic, fine, wd | 1 | 65 | 0.28 |
| 113 | Slate belt, fine, wd | 2 | 82 | 0.38 |
| | Mountain | | | |
| 205 | Flood plains, loamy, swpd to wd | 3 | 230 | 0.48 |
| 206 | Terrace-toe slope, fine loamy, mwd to wd | 1 | 126 | 0.64 |
| 215 | Terrace, argillic horizon, fine loamy, wd | 1 | 119 | 0.40 |

[#] Drainage class: vpd- very poorly drained; pd – poorly drained; mwd – moderately well drained; wd – well drained; ewd – excessively well drained; swpd – somewhat poorly drained.

Once the yield response curves were developed, the optimum N rates and N factors could be determined (Table 2). These new values (Mea) were compared to the current information (Std) in the RYE data table for each experiment. Mean values for optimum yield and N rate, as well as N factor were calculated for each physiographic region: Coastal Plain, Piedmont and Mountains.

Table 2. Comparisons of mean optimum yields, optimum N rates and N factors between the standard (Std.) RYE database and measured (Mea.) field experiment values for Soil Management Groups.

| | | **Optimum Yield** | | | **Optimum N Rate** | | | **N Factor** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **SMG** | **N** | **Std.** | **Mea.** | **SD[1]** | **Std.[2]** | **Mea.** | **SD** | **Std.** | **Mea.[3]** | **SD** |
| | | | bu/ac | | | lb/ac | | | lb N/bu | |
| Coastal Plain | | | | | | | | | | |
| 2 | 3 | 130 | 161 | 29 | 116 | 120 | 22 | 1.06 | 0.89 | 0.10 |
| 3 | 1 | 150 | 181 | -- | 137 | 81 | -- | 1.06 | 0.57 | -- |
| 6 | 8 | 146 | 150 | 21 | 139 | 164 | 47 | 1.06 | 1.21 | 0.28 |
| 7 | 13 | 135 | 162 | 32 | 135 | 138 | 36 | 1.11 | 0.97 | 0.28 |
| 10 | 4 | 138 | 167 | 36 | 124 | 143 | 39 | 1.06 | 0.99 | 0.12 |
| 11 | 1 | 120 | 183 | -- | 130 | 134 | -- | 1.08 | 0.73 | -- |
| 12 | 3 | 130 | 149 | 57 | 118 | 96 | 26 | 1.08 | 0.91 | 0.53 |
| 20 | 1 | 130 | 149 | -- | 126 | 75 | -- | 1.14 | 0.65 | -- |
| 25 | 2 | 115 | 128 | 72 | 105 | 134 | 48 | 1.14 | 1.34 | 0.34 |
| 27 | 1 | 75 | 114 | -- | 70 | 130 | -- | 1.22 | 1.33 | -- |
| *Mean* | *37* | *134* | *157** | *33* | *128* | *136* | *40* | *1.09* | *1.02* | *0.31* |
| Piedmont | | | | | | | | | | |
| 109 | 1 | 132 | 201 | -- | 125 | 123 | -- | 1.11 | 0.72 | -- |
| 111 | 1 | 119 | 111 | -- | 132 | 130 | -- | 1.11 | 1.17 | -- |
| 113 | 2 | 114 | 136 | 6 | 101 | 126 | 57 | 1.08 | 1.08 | 0.37 |
| *Mean* | *4* | *120* | *146* | *39* | *115* | *126* | *33* | *1.10* | *1.01* | *0.29* |
| Mountain | | | | | | | | | | |
| 205 | 3 | 155 | 272 | 11 | 142 | 86 | 40 | 1.06 | 0.40 | 0.14 |
| 206 | 1 | 172 | 191 | -- | 177 | 80 | -- | 1.03 | 0.42 | -- |
| 215 | 1 | 201 | 209 | -- | 223 | 180 | -- | 1.11 | 0.86 | -- |
| *Mean* | *5* | *168* | *243** | *41* | *165* | *104* | *51* | *1.06* | *0.49** | *0.23* |

[1] Standard deviation of the mean for measured values in the field experiments.
[2] If the previous crop was a legume, the standard N rate was adjusted as follows: ((Std Optimum Yield x Std N factor) – legume credit); legume credit was 22 lb N/ac for soybean and 30 lb N/ac for peanut.
[3] If the previous crop was legume, the measured N factor was adjusted as follows: (Mea. Optimum N Rate + Legume Credit)/(Mea. Optimum Yield).
* Indicates the 95% confidence interval is different between the standard and measured values.

In reviewing these data, it appeared that optimum N rates of the experimental data agree very well with recommended N rates. However, yields have increased by 15%, 18% and 31% respectively for the Coastal Plain, Piedmont and Mountains. The INMC decided to increase yields 20% for all soils except floodplain soils in the mountains. The yield for these mountain

soils will be increased to 250 bu/ac, the N fertilizer rate will remain stable, and the N factor will be adjusted accordingly. Since N rate recommendations are stable for all other soils, N factors were determined for each soil series by dividing the current N rate by the revised yield. Currently, N factors are based on SMGs. Now they will be a function of the individual soil series.

The INMC reviewed the experiments by tillage. It is frequently suggested that long-term conservation tillage requires less N. Our data do not support this contention (Table 3).

Table 3. Comparisons of mean optimum yields, optimum N rates and N factors between the standard (Std.) RYE database and measured (Mea.) field values from experiments with different tillage practices.

| | | Optimum Yield | | | Optimum N Rate | | | N Factor | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Tillage** | **N** | **Std.** | **Mea.** | **SD[1]** | **Std.[2]** | **Mea.** | **SD** | **Std.** | **Mea.[3]** | **SD** |
| | | | bu/ac | | | lb N/ac | | | lb N/bu | |
| Conventional | 21 | 141 | 172 | 52 | 137 | 134 | 53 | 1.09 | 0.96 | 0.42 |
| No-till<10 yr | 18 | 132 | 152 | 37 | 125 | 127 | 28 | 1.08 | 1.00 | 0.27 |
| No-till>10 yr | 7 | 135 | 177* | 20 | 127 | 135 | 37 | 1.08 | 0.86* | 0.13 |

[1] Standard deviation of the mean for measured values in the field experiments.
[2] If the previous crop was a legume, the standard N rates was adjusted as follows: ((Std Optimum Yield x Std N factor) – legume credit); legume credit was 22 lb N/ac for soybean and 30 lb N/ac for peanut.
[3] If the previous crop was legume, the measured N factor was adjusted as follows: (Mea. Optimum N Rate + Legume Credit)/(Mea. Optimum Yield).
* Indicates the 95% confidence interval is different between the standard and measured values.

Corn is often preceeded by soybeans or peanuts, which can provide additional N. The analysis of N fertilizer rates relative to the prior crop demonstrates that the credit for soybeans (15-30 lb N/ac/yr) and peanuts (20-40 lb N/ac/yr) are justifiable and should be continued (Figure 4).

Table 4. Comparisons of mean optimum yields, optimum N rates and N factors between the standard (Std.) RYE database and measured (Mea.) field values where corn was preceded by different crops.

| **Previous** | | Optimum Yield | | | Optimum N Rate | | | N Factor | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Crop** | **N** | **Std.** | **Mea.** | **SD[1]** | **Std.[2]** | **Mea.** | **SD** | **Std.** | **Mea.[3]** | **SD** |
| | | | bu/ac | | | lb N/ac | | | lb N/bu | |
| Corn | 5 | 132 | 146 | 23 | 144 | 167 | 58 | 1.09 | 1.15 | 0.34 |
| Cotton | 1 | 135 | 120 | -- | 150 | 120 | -- | 1.11 | 1.24 | -- |
| Fallow | 2 | 186 | 200 | 13 | 200 | 130 | 71 | 1.07 | 0.64 | 0.31 |
| Peanut | 1 | 115 | 179 | -- | 101 | 168 | -- | 1.14 | 1.11 | -- |
| Potato | 1 | 135 | 150 | -- | 150 | 105 | -- | 1.11 | 0.70 | -- |
| Soybean | 35 | 135 | 167* | 46 | 125 | 126 | 38 | 1.09 | 0.95* | 0.34 |
| Wheat | 1 | 120 | 183 | -- | 130 | 134 | -- | 1.08 | 0.73 | -- |

[1] Standard deviation of the mean for measured values in the field experiments.
[2] If the previous crop was a legume, the standard N rates was adjusted as follows: ((Std Optimum Yield x Std N factor) – legume credit); legume credit was 22 lb N/ac

for soybean and 30 lb N/ac for peanut.
[3] If the previous crop was legume, the measured N factor was adjusted as follows:
(Mea. Optimum N Rate + Legume Credit)/(Mea. Optimum Yield).
* Indicates the 95% confidence interval is different between the standard and measured values.