| | | |
|---|---|---|
| Mora | (4) | (23) |
| Corn | 7 | 57 |
| Oats | 4 | 50 |
| Mixed leg.-grass | 4 | 3.2 |
| Corn silage | 3 | 8.3 |
| Nebish | (7) | (39) |
| Oats | 10 | 47 |
| Alfalfa | 7 | 1.7 |
| Alfalfa-brome | 9 | 4.3 |
| Alfalfa-brome-past. | 7 | 78 |
| Nicollet | (21) | (104) |
| Corn | 43 | 75 |
| A-1 | 22 | 81 |
| B-1 | 13 | 75 |
| Oats | 15 | 59 |
| Soybeans | 13 | 30 |
| Spring wheat | 4 | 32 |
| Barley | 2 | 94 |
| Alfalfa | 13 | 3.7 |
| Alfalfa brome | 4 | 4.0 |
| Corn silage | 4 | 7.9 |
| Nokay | (5) | (20) |
| Corn | 7 | 54 |
| Oats | 5 | 42 |
| Corn silage | 6 | 8.0 |
| Nymore | (3) | (5) |
| Alfalfa | 2 | 1.8 |
| Onamia | (5) | (23) |
| Oats | 5 | 63 |
| Corn | 6 | 71 |
| Alfalfa | 4 | 3.5 |
| Alfalfa-brome | 2 | 1.8 |
| Pasture (brome) | 2 | 200 |
| Ostrander | (7) | (22) |
| Corn | 8 | 77 |
| Soybeans | 3 | 27 |
| Alfalfa | 3 | 4.5 |
| Parent | (1) | (1) |
| Parnell | (2) | (11) |
| Corn | 6 | 53 |
| Oats | 3 | 77 |
| Deep Peat | (6) | (26) |
| Corn | 4 | 71 |
| Soybeans | 3 | 24 |
| Timothy (seed) | 3 | 334 |
| Corn silage | 2 | 6.5 |
| Pasture (other) | 5 | 119 |
| Leg,-grass past. | 2 | 242 |
| Shallow Peat | (5) | (7) |
| Soybeans | 3 | 24 |
| Barley | 2 | 56 |
| Pierce | (1) | (1) |
| Racine | (1) | (1) |
| Redby | (3) | (16) |
| Leg.-grass hay | 3 | 1.5 |
| Leg.-grass past | 5 | 88 |
| RCl-tim hay | 7 | 2.5 |
| Oats | 2 | 40 |
| Rocksbury | (12) | (41) |
| Oats | 10 | 60 |
| Flax | 5 | 8 |
| Alfalfa | 3 | 2.9 |
| Hay (other) | 6 | 1.5 |
| Sweet corn-brome | 2 | |
| Pasture (other) | 3 | 117 |
| Wheat | 5 | 23 |
| Rockwell | (5) | (17) |
| Oats | 3 | 52 |
| Barley | 4 | 25 |
| Alfalfa | 2 | 1.7 |
| Corn silage | 2 | 12.9 |
| Wheat | 2 | 29 |
| Rothsay | (1) | (1) |
| Sioux | (4) | (11) |
| Oats | 5 | 37 |
| Soybeans | 2 | 12 |
| Alfalfa | 2 | 0.8 |
| Shooks | (2) | (9) |
| Oats | 5 | 48. |
| Alfalfa | 2 | 2.0 |
| Skyberg | (3) | (12) |
| Corn | 5 | 78 |
| Oats | 2 | 83 |
| Leg.-grass past. | 2 | 154 |
| Sletton | (1) | (5) |
| Soybeans | 3 | 30 |
| Storden-Clarion | (1) | (7) |
| Oats | 2 | 80 |
| Alfalfa | 5 | 2.9 |
| Tama | (8) | (48) |
| Oats | 15 | 72 |
| Corn | 14 | 91 |
| A-1 | 6 | 87 |
| B-1 | 4 | 97 |
| B-2 | 2 | 106 |
| C-1 | 2 | 43 |
| C-2 | 1 | 43 |
| Corn silage | 3 | 14.2 |
| Alfalfa | 6 | 4.2 |
| Alflafa-brome | 4 | 4.3 |

| | | |
|---|---|---|
| Leg.-grass hay | 4 | 3.3 |
| Alfalfa-brome past. | 3 | 178 |
| **Taylor** | (1) | (5) |
| Oats | 3 | 45 |
| Alfalfa | 2 | 1.7 |
| **Terrill** | (1) | (2) |
| **Todd** | (2) | (8) |
| Alfalfa-brome | 4 | 2.2 |
| Corn silage | 3 | 7.0 |
| **Truman** | (3) | (10) |
| Corn | 4 | 90 |
| **Ulen** | (4) | (29) |
| Oats | 10 | 50 |
| Corn | 6 | 52 |
| Corn silage | 2 | 15.5 |
| Alfalfa | 3 | 2.3 |
| **Vallers** | (3) | (17) |
| Corn | 4 | 55 |
| Oats | 2 | 63 |
| Soybean | 6 | 21 |
| **Varco** | (1) | (6) |
| Corn | 4 | 88 |
| Alfalfa-brome | 2 | 2.8 |
| **Vienna** | (2) | (6) |
| Corn | 3 | 63 |
| Oats | 2 | 60 |
| **Wabash** | (1) | (4) |
| Corn | 3 | 109 |
| **Wadena** | (4) | (18) |
| Corn | 7 | 76 |
| Soybean | 4 | 21 |
| Oats | 3 | 80 |
| **Waukegan** | (9) | (38) |
| Corn | 15 | 74 |
| A-1 | 7 | 76 |
| B-1 | 7 | 71 |
| Alfalfa-brome | 3 | 3.1 |
| Oats | 8 | 81 |
| Alfalfa | 4 | 1.9 |
| Soybeans | 2 | 33 |
| **Waukon** | (10) | (42) |
| Corn | 10 | 63 |
| Oats | 7 | 57 |
| Barley | 4 | 36 |
| Spring wheat | 3 | 30 |
| Alfalfa | 10 | 2.2 |
| Mix.leg.-grass | 3 | 4.1 |
| **Webster** | (39) | (161) |
| Corn | 73 | 87 |
| Oats | 28 | 63 |
| Soybeans | 20 | 21 |
| Alfalfa | 17 | 4.2 |
| Alfalfa-brome | 9 | 2.8 |
| Corn silage] | 5 | 10.1 |
| Alfalfa-brome past. | 2 | 75 |
| Mix-Leg grass | 2 | 3.2 |
| **Webster Calc. Var.** | (8) | (37) |
| Corn | 12 | 89 |
| Oats | 3 | 85 |
| Soybeans | 10 | 34 |
| Alfalfa | 4 | 3.2 |
| **Wildwood** | (2) | (7) |
| Oats | 2 | 33 |
| **Winger** | (4) | (24) |
| Oats | 9 | 76 |
| Barley | 5 | 40 |
| Spring wheat | 4 | 29 |
| Alfalfa | 3 | 1.6 |
| **Zimmerman** | (3) | (16) |
| Corn | 3 | 62 |
| Oats | 2 | 57 |
| Corn silage | 4 | 9.7 |
| Hay (other) | 3 | 9.4 |

Grand total as of December 1965

| No. Fields | No. Yields |
|---|---|
| 548 | 2259 |

# SOILS AND CROP MANAGEMENT SYSTEMS

West Central Experiment Station

Roy L. Thompson, Samuel D. Evans, and Lowell Hanson

All yields were very high in 1965 due to above normal precipitation. Corn yields were 31.5 bu./acre higher on the test than on the base plots. Soybean yields were moderately high with the test plot yielding 3.4 bu./acre more than the base plots. Alfalfa yields were extremely high with a top yield of 6.0 tons/acre on the continuous alfalfa base treatment plots. The 1960-65 yields are given in the following table. For treatments see the February 1965 Blue Book.

| | Base Management | Test Management |
|---|---|---|
| | Continuous Soybeans | |
| 1960 | 16.8 bu./A | 23.1 bu./A |
| 1961 | 20.7 | 28.4 |
| 1962 | 21.2 | 26.4 |
| 1963 | 23.4 | 36.7 |
| 1964 | 15.6 | 22.1 |
| 1965 | 24.7 | 28.1 |
| Average | 20.4 | 27.5 |
| | Continuous Corn | |
| 1960 | 61.2 bu./A | 70.3 bu./A |
| 1961 | 62.0 | 65.5 |
| 1962 | 67.0 | 87.4 |
| 1963 | 72.7 | 73.1 |
| 1964 | 36.7 | 34.2 |
| 1965 | 69.5 | 101.0 |
| Average | 61.6 | 71.9 |

| | Base Management | Test Management |
|---|---|---|
| | **Continuous Alfalfa** | |
| 1960 | 1.4 tons/A | 1.8 tons/A |
| 1961 | 2.2 | 2.0 |
| 1962 | 4.8 | 5.1 |
| 1963 | 4.9 | 4.9 |
| 1964 | 3.0 | 3.1 |
| 1965 | 6.0 | 5.4 |
| Averages | 3.7 | 3.7 |
| | **Rotation Plots** | |
| 1960 (oats) Grain: | 86.7 bu./A | 90.0 bu./A |
| Silage: | 7.9 tons/A (Green wt.) | 8.2 tons/A (Green wt.) |
| 1961 (alfalfa) After Grain: | 1.87 tons/A | 1.79 tons/A |
| After Silage | 2.44 tons/A | 2.19 tons/A |
| 1962 (Soybeans) | 24.1 Bu./A | 25.6 Bu./A |
| 1963 (Corn) = | 86.4 Bu./A | 113.9 Bu./A |
| 1964 (Oats) Grain: | 65.1 Bu./A | 94.2 Bu./A |
| Silage: | 1.14 tons/A (Dry wt.) | 1.76 tons/A (Dry wt.) |
| 1965 (alfalfa) After Grain: | 5.1 tons/A | 5.3 tons/A |
| After Silage: | 4.8 tons/A | 5.4 tons/A |

## Continuous Soybean Fertility Study (Rosemount, 1965).

Dr. A. C. Caldwell, E. C. Seim, G. W. Rehm

Soybeans have been grown continuously on a Port Byron silt loam at Rosemount, Minnesota, since 1957. Fertilizer treatments consisting of varying rates of P and K were applied at the start of the experiment. No additional fertilizer has ever been applied.

In the eighth crop following the fertilizer applications bean yields were generally low due to late planting and a cold spring and early fall which delayed maturity. The yields are reported in Table 1. It is amazing to note that although all the differences may not be significantly different from the control mean, all treatments gave increases over the check. The yields of those plots which received the 0-400-400 fertilizer application in 1957 averaged 4 bushels higher than the unfertilized plots.

Table 1. Residual effect of fertilizer treatments on the yield of soybeans grown continuously (Rosemount, 1965)

| | Treatment: (applied in 1957) | | | 1965 Yield | |
|---|---|---|---|---|---|
| No. | P | K | Manure | Bu./acre | Diff. |
| 1 | 0 | 0 | | 11.6 | --- |
| 2 | 20 | 20 | | 12.7 | +1.1 |
| 3 | 40 | 40 | | 12.7 | +1.1 |
| 4 | 60 | 60 | | 12.3 | +0.7 |
| 5 | 80 | 80 | | 13.4 | +1.8 |
| 6 | 400 | 400 | | 15.9 | +4.3 |
| 7 | 400 | 400 | 6 ton | 13.8 | +2.2 |
| 8 | 20 | 0 | | 12.6 | +1.0 |
| 9 | 20 | 20 | | 12.3 | +0.7 |
| 10 | 80 | 0 | | 14.7 | +3.1 |
| 11 | 0 | 80 | | 12.4 | +0.8 |
| 12 | 400 | 0 | | 15.0 | +3.4 |
| 13 | 0 | 400 | | 14.3 | +2.7 |
| 14 | 0 | 0 | 6 ton | 14.6 | +3.0 |
| 15 | 20 | 0 | 6 ton | 13.1 | +1.5 |

lsd (.95)
hsd (.95)

# FERTILIZER ROTATION EXPERIMENT

West Central Experiment Station

Samuel D. Evans and A.C. Caldwell

An NPK factorial expeririment involving the three nutrients alone and in all combinations applied across a five-year rotation and continuous corn has been in existence ten years. Treatments, rates and yields are given in the following tables:

Table 1. Yield of Continuous Corn

| Treatment | $N-P_2O_5-K_2O$ Lbs./A | Av. Yield Bu./A | Diff. from Untreated | Treatment Effect | 1956-65 Av. Yield Bu./A | 1956-65 Treatment Effect |
|---|---|---|---|---|---|---|
| None | 0+0+0 | 61.75 | - - | - - | 59.3 | - - |
| N | 160+0+0 | 115.35 | +53.60 | +49.69** | 75.8 | +24.4 |
| P | 0+140+0 | 67.09 | +5.31 | +6.13 | 55.0 | -0.1 |
| K | 0+0+40 | 63.36 | +1.61 | +1.57 | 54.8 | -0.1 |
| NP | 144+140+0 | 116.50 | +54.75 | -1.12 | 81.7 | +2.8 |
| NK | 160+0+40 | 111.12 | +49.37 | -1.81 | 81.7 | +2.8 |
| PK | 0+140+40 | 72.26 | +10.51 | +2.89 | 53.5 | 0.8 |
| NPK | 144+140+40 | 120.26 | +58.51 | +0.99 | 81.2 | +2.4 |
| NPK+ | 304+320+80 | 96.36 | +34.61 | - - | 71.6 | - - |

Table 2. Yield of First-Year Corn

| Treatment | $N-P_2O_5-K_2O$ Lbs./A | Av. Yield Bu./A | Diff. from Untreated | Treatment Effect | 1956-65 Av. Yield Bu./A | 1956-65 Treatment Effect |
|---|---|---|---|---|---|---|
| None | 0+0+0 | 88.81 | - - | - - | 68.9 | - - |
| N | 60+0+0 | 88.19 | -0.62 | +12.68** | 70.8 | +1.3 |
| P | 0+20+0 | 116.04 | +27.23 | +32.93** | 78.3 | +8.6 |
| K | 0+0+40 | 72.06 | -16.75 | -1.48 | 65.7 | -2.6 |
| NP | 44+20+0 | 127.08 | +38.27 | -2.05 | 77.6 | -0.7 |
| NK | 60+0+40 | 102.23 | +13.42 | +7.52 | 67.8 | +0.7 |
| PK | 0+20+40 | 114.80 | +25.99 | -0.12 | 75.0 | +0.5 |
| NPK | 44+20+40 | 125.12 | +36.31 | -8.38 | 76.8 | +0.6 |
| NPK+ | 84+100+80 | 120.46 | +31.65 | - - | 77.6 | - - |

Table 3. Yield of Second-Year Corn

| Treatment | $N-P_2O_5-K_2O$ Lbs./A | Av. Yield Bu./A | Diff. from Untreated | Treatment Effect | 1956-65 Av. Yield Bu./A | 1956-65 Treatment Effect |
|---|---|---|---|---|---|---|
| None | 0+0+0 | 95.37 | - - | - - | 73.0 | - - |
| N | 80+0+0 | 98.10 | +2.73 | +20.02** | 76.1 | +5.7 |
| P | 0+60+0 | 79.76 | -15.61 | +6.26 | 73.6 | +4.7 |
| K | 0+0+40 | 73.28 | -22.09 | +2.06 | 66.5 | -2.4 |
| NP | 64+60+0 | 108.90 | +13.53 | +1.80 | 80.1 | +1.0 |
| NK | 80+0+40 | 106.99 | +11.62 | +4.09 | 72.9 | +0.9 |
| PK | 0+60+40 | 97.80 | +2.43 | +8.66 | 73.4 | +2.4 |
| NPK | 64+60+40 | 112.30 | +16.93 | -11.40 | 80.4 | -0.7 |
| NPK+ | 104+100+80 | 104.76 | +9.39 | - - | 79.7 | - - |

Table 4. Yield of Soybeans

| Treatment | $N-P_2O_5-K_2O$ Lbs./A | Av. Yield Bu./A | Diff. from Untreated | Treatment Effect | 1956-65 Av. Yield Bu./A | 1956-65 Treatment Effect |
|---|---|---|---|---|---|---|
| None | 0+0+0 | 27.92 | - - | - - | 23.9 | - - |
| N | 20+0+0 | 29.09 | +1.17 | -0.78 | 24.7 | +0.5 |
| P | 0+40+0 | 33.78 | +5.86 | +5.12** | 26.5 | +1.7 |
| K | 0+0+40 | 29.94 | +2.02 | +2.01 | 24.1 | +0.2 |
| NP | 20+40+0 | 33.00 | +5.08 | -1.70 | 26.5 | -0.2 |
| NK | 20+0+40 | 30.64 | +2.72 | -0.96 | 24.9 | +0.2 |
| PK | 0+40+40 | 37.71 | +9.79 | +0.22 | 26.4 | +0.7 |
| NPK | 20+40+40 | 33.54 | +5.62 | -0.73 | 27.1 | +0.2 |
| NPK+ | 40+80+80 | 34.38 | +6.46 | - - | 27.9 | - - |

Table 5. Yield of Flax

| Treatment | $N-P_2O_5-K_2O$ Lbs./A | Av. Yield Bu./A | Diff. from Untreated | Treatment Effect | 1956-65 Av. Yield Bu./A | 1956-65 Treatment Effect |
|---|---|---|---|---|---|---|
| None | 0+0+0 | 28.93 | - - | - - | 20.5 | - - |
| N | 60+0+0 | 30.40 | +1.47 | 2.98** | 20.2 | +0.1 |
| P | 0+40+0 | 28.44 | -0.49 | +0.57 | 19.5 | -0.3 |
| K | 0+0+20 | 28.38 | -0.55 | -0.76 | 20.1 | +0.7 |
| NP | 60+40+0 | 32.44 | +3.51 | +1.51 | 20.5 | -0.5 |
| NK | 60+0+20 | 29.85 | +0.92 | +0.24 | 21.8 | -0.2 |
| PK | 0+40+20 | 26.99 | -1.94 | -0.20 | 21.4 | +0.1 |
| NPK | 60+40+20 | 31.96 | +3.03 | +0.24 | 19.9 | -1.1 |
| NPK+ | 120+80+40 | 32.15 | +3.22 | - - | 21.7 | - - |

Table 6. Yield of Alfalfa

| Treatment | $N-P_2O_5-K_2O$ Lbs./A | | 1956-64 Av. Yield Tons/A | 1956-64 Treatment Effect |
|---|---|---|---|---|
| None | 0+0+0 | Yields were not taken in 1965. | 2.50 | - - |
| N | 20+0+0 | | 2.34 | -0.11 |
| P | 0+80+0 | | 3.84 | +1.25 |
| K | 0+0+40 | | 2.11 | -0.01 |
| NP | 20+80+0 | | 3.27 | -0.22 |
| NK | 20+0+40 | | 2.48 | +0.25 |
| PK | 0+80+40 | | 3.70 | +0.11 |
| NPK | 20+80+40 | | 3.61 | -0.01 |
| NPK+ | 20+160+80 | | 3.60 | - - |

# Continuous Corn - High Fertility Experiment
## Rosemount Experiment Station
## Established - 1953

W. P. Martin, P. M. Burson, and G. W. Randall

Yield results 1965 (For experimental design and past years results see p. 47 in the in the mimeographed "Bluebook," February 1963, p. 67, Jan. 1964, and p. 33, Feb. 1965.

| Fertilizer Treatments* | Yield Bu./Acre | | Yield Inc./#N | |
|---|---|---|---|---|
| | 16,500 plants | 19,500 plants | 16,500 plants | 19,500 plants |
| 1. Check | 30.2 | 40.5 | -- | -- |
| 2. 16 + 32 + 32 | 52.8 | 71.8 | -- | -- |
| 3. 49 + 32 + 32 | 67.5 | 96.2 | .30 | .50 |
| 4. 82 + 32 + 32 | 79.0 | 101.8 | .32 | .37 |
| 5. 32 + 80 + 128 | 56.5 | 68.2 | -- | -- |
| 6. 65 + 80 + 128 | 80.8 | 99.2 | .37 | .48 |
| 7. 98 + 80 + 128 | 96.0 | 109.0 | .40 | .42 |
| 8. 48 + 128 + 224 | 59.0 | 94.2 | -- | -- |
| 9. 81 + 128 + 224 | 95.8 | 110.8 | .45 | .21 |
| 10. 104 + 128 + 224 | 104.8 | 114.5 | .44 | .20 |

* #N + #$P_2O_5$ + #$K_2O$

The 1965 yield data indicate a tremendous response to nitrogen fertilization. This response can be measured by the yield increase per pound of N applied as indicated by the table above. The late, cold, wet spring along with a cool moist growing season and the 13 year duration of this experiment may be the explanation of this N response.

# ALFALFA EXPERIMENT 1965

Pierz (Morrison Co.), Minnesota
C. J. Overdahl, L. D. Hanson
University of Minnesota

Experimental plots were established to determine needed rates of potassium, phosphorus and lime for alfalfa on sandy soils.

Five rates of potassium were applied at seeding time. Each of these plots were split three ways for topdressing. Adequate rates of phosphorus, lime, sulfur and boron were applied.

In a second plot, adequate lime, sulfur and boron were applied to all plots. Three rates of phosphorus and three rates of lime were applied. All plots were replicated four times.

## Potassium Experiment:

B = Basic $K_2O$ treatment per acre at seeding time
T = Topdressed $K_2O$ treatment fall of 1964
Yields = Tons per acre at 20% moisture

| Cutting | $B_0$ $T_0$ | $B_0$ $T_{120}$ | $B_0$ $T_{240}$ | $B_{60}$ $T_0$ | $B_{60}$ $T_{120}$ | $B_{60}$ $T_{240}$ |
|---|---|---|---|---|---|---|
| 1 | 1.58 | 2.22 | 2.12 | 1.70 | 2.24 | 2.38 |
| 2 | 1.72 | 2.02 | 2.36 | 1.74 | 2.14 | 2.16 |
| 3 | .72 | .92 | 1.00 | .72 | .89 | 1.10 |
| Total | 4.02 | 5.16 | 5.48 | 4.16 | 5.27 | 5.64 |
| T Increase | - | 1.14 | 1.46 | - | 1.11 | 1.48 |

| Cutting | $B_{120}$ $T_0$ | $B_{120}$ $T_{120}$ | $B_{120}$ $T_{240}$ | $B_{180}$ $T_0$ | $B_{180}$ $T_{120}$ | $B_{180}$ $T_{240}$ |
|---|---|---|---|---|---|---|
| 1 | 1.80 | 2.49 | 2.52 | 2.24 | 2.32 | 2.35 |
| 2 | 1.95 | 2.40 | 2.52 | 2.00 | 2.18 | 2.34 |
| 3 | .75 | 1.00 | 1.14 | .84 | .96 | 1.07 |
| Total | 4.50 | 5.89 | 6.18 | 5.08 | 5.46 | 5.76 |
| T Increase | - | 1.39 | 1.60 | - | .38 | .68 |

| Cutting | $B_{240}$ $T_0$ | $B_{240}$ $T_{120}$ | $B_{240}$ $T_{240}$ |
|---|---|---|---|
| 1 | 2.28 | 2.37 | 2.52 |
| 2 | 2.12 | 2.15 | 2.36 |
| 3 | .96 | 1.05 | 1.15 |
| Total | 5.36 | 5.57 | 6.03 |
| T Increase | - | .21 | .67 |

| Calculated Check Plot Yields* |
|---|
| 1.06 |
| 1.26 |
| .45 |
| 2.77 |

*Lime and P response deducted from K check plots.

Summary of Potassium Plots (2 years 1964 and 1965)

Plots with no topdressing ($T_0$ 2 years)

| Year | Cutting | $B_0$ | $B_{60}$ | $B_{120}$ | $B_{180}$ | $B_{240}$ |
|---|---|---|---|---|---|---|
| 1964 | 1 | 1.33 | 1.46 | 1.57 | 1.61 | 1.72 |
| | 2 | .98 | .94 | 1.03 | 1.09 | 1.28 |
| 1964 Total | | 2.31 | 2.40 | 2.60 | 2.70 | 3.00 |
| 1965 | 1 | 1.58 | 1.70 | 1.80 | 2.24 | 2.28 |
| | 2 | 1.72 | 1.74 | 1.95 | 2.00 | 2.12 |
| | 3 | .72 | .72 | .75 | .84 | .96 |
| 1965 Total | | 4.02 | 4.16 | 4.50 | 5.08 | 5.36 |
| 2-Year Total | | 6.33 | 6.56 | 7.10 | 7.78 | 8.36 |
| 2-Year Increases | | - | .23 | .77 | 1.45 | 2.03 |

Summary of K Experiment:

A top yield of 6.18 tons per acre was obtained. The check yield of 4.02 tons is unusually high for this soil. Rainfall was above normal until the time of the second cutting. If rains had continued, a higher yield would have been obtained from the third cutting (August 31).

The dry weather continued after the last cutting with a regrowth of only 2 or 3 inches at the most. Plots were again topdressed in October, 1965.

There is an unexplained, comparatively high yield on the 120 pound and 240 pound topdressings on the 120 pound seeding time basic treatment. This does not appear in the $T_0$ of this basic treatment. The response curve of all seeding time treatments is a straight line upward from $B_0$ to $B_{240}$. A similar straight line does not occur when averages of all three topdressing treatments within each seeding time basic treatment are averaged. The highest yield occuring with the $B_{120}$ treatment. A similar comparatively high yield was obtained in 1964 when the T treatments were all zero. Topdressing was not started until after the first harvest year.

Actually, the topdressing results are perhaps best indicated by observing $B_0$ and $B_{240}$. The 1.49 ton increase from $T_{240}$ where no potassium was applied at seeding time ($B_0$) compares to a $T_{240}$ increase of .67 tons on the 240 pounds $K_2O$ seeding time treatment ($B_{240}$). A lower but similar relationship is observed with the 120 pound topdressing of $K_2O$between these two basic treatments.

Summary of Lime - P Plots

| Year | Cutting | Lime Rates Tons/Acre $L_0$ | $L_{2\frac{1}{2}}$ | $L_5$ |
|---|---|---|---|---|
| 1964 | 1 | 1.27 | 1.41 | 1.55 |
| | 2 | 0.99 | 1.08 | 1.10 |
| 1965 | 1 | 2.33 | 2.35 | 2.48 |
| | 2 | 2.13 | 2.16 | 2.25 |
| | 3 | .91 | 1.01 | 1.05 |
| Total | | 7.63 | 8.01 | 8.43 |
| 2-Year Increase | | | .38 | .80 |

| Year | Cutting | Rates of $P_2O_5$/Acre Annually $P_0$ | $P_{30}$ | $P_{60}$ |
|---|---|---|---|---|
| 1964 | 1 | 1.29 | 1.40 | 1.53 |
| | 2 | 0.99 | 1.18 | 1.19 |
| 1964 Total | | 2.28 | 2.58 | 2.72 |
| 1965 | 1 | 2.06 | 2.48 | 2.63 |
| | 2 | 1.99 | 2.23 | 2.33 |
| | 3 | .92 | 1.00 | 1.05 |
| 1965 Total | | 4.97 | 5.71 | 6.01 |
| 2-Year Total | | 7.25 | 8.29 | 8.73 |
| Average per year | | 3.62 | 4.14 | 4.36 |
| $P_2O_5$ Increase/average per year | | - | .52 | .74 |

| pH | P | K | Soil |
|---|---|---|---|
| 6.3 | 19 Med-High | 50 Very low | Brainerd sandy loam |

Summary:

There appears to be a lime response with the pH at 6.3. Two and one-half tons of lime changed the pH to 6.7 and five tons increased the pH to 7.0.

There is a definite phosphorus response.

## RESULTS AT DULUTH

In fall 1960 a study was undertaken at the Duluth Station to determine the effect of various levels of potassium on alfalfa yield, tissue analysis, and soil test. Treatments of 0, 120, 240, 480 and 960 pounds of $K_2O$ per

acre were broadcast and plowed under in fall 1960 and the plots were seeded to an alfalfa-grass mixture with oats as a nurse crop in spring 1961. Phosphorus, lime, and boron were applied in adequate amounts to all plots. In 1963, 200 pounds per acre of $K_2O$ were topdressed on half of each of the plots after the first cutting.

Simple economics show that best profits from potassium use are among the high treatments.

If the potassium treatments continue to produce the above yield trends, it appears that the greatest profit increase will be from the very high levels of potassium.

Alfalfa-brome Yields in Tons per Acre According to Potash Treatment with Related Soil Tests and Tissue Analysis*

| $K_2O$ lb/A. | 1962 | 1963 | 1964** | 1965 | Average | K Soil Test | Average % K and relative level |
|---|---|---|---|---|---|---|---|
| 0 | 2.7 | 2.4 | 1.1 | 2.2 | 2.1 | 70 Low | 1.00 deficient |
| 120 | 3.1 | 3.0 | 1.5 | 3.2 | 2.7 | 80 Low | 1.40 deficient |
| 240 | 3.5 | 3.7 | 1.6 | 3.0 | 3.0 | 83 Low | 1.44 deficient |
| 480 | 3.4 | 3.9 | 2.0 | 3.5 | 3.2 | 106 Med. | 1.78 low |
| 960 | 3.6 | 4.3 | 2.5 | 3.5 | 3.5 | 203 Med-H. | 2.33 sufficient |

* Data by Grant, Hopen, Caldwell, and Baker
** Sampled at 0- to 6-inch depth in fall 1963 (3 years after application.)

Four-Year Net Returns from Varying Potassium Treatments

| $K_2O$ lb./A. | 4-Yr. Increase over check, Tons/Acre | 4-Yr. Gross Returns* | K Fertilizer Cost** | 4-Yr. Net Profit Increase |
|---|---|---|---|---|
| 120 | 2.19 | $43.80 | $ 5.50 | $38.30 |
| 240 | 3.34 | 66.80 | 11.00 | 55.00 |
| 480 | 4.20 | 84.00 | 22.00 | 62.00 |
| 960 | 5.23 | 104.60 | 44.00 | 60.60 |

* $20 per ton of alfalfa
** $K_2O$ figured at $55 per ton.

Topdressing Effect on 1964 Yield, Surface Soil Test, and Tissue Analysis

| $K_2O$ lb/Acre Broadcast 1960 | | Topdressed 1963 | Yield 1964 | Yield 1965 | 2-Yr. increase | K Soil Test | % K Tissue and Relative Level |
|---|---|---|---|---|---|---|---|
| 120 | | --- | 1.5 | 2.5 | -- | 80 low | 1.33 deficient |
| 120 | + | 200 | 1.8 | 3.2 | 1.0 | 140 medium | 2.42 sufficient |
| 240 | | -- | 1.6 | 2.5 | -- | 83 low | 1.46 deficient |
| 240 | + | 200 | 2.1 | 3.0 | 1.0 | 146 medium | 2.55 sufficient |
| 480 | | -- | 2.0 | 2.9 | -- | 106 medium | 1.87 deficient |
| 480 | + | 200 | 2.3 | 3.5 | 0.9 | 246 high | 2.56 sufficient |

## Rosemount Soils Farm

### Rosamount Agricultural Experiment Station
### 1965

*Paul M. Burson and E. G. Bonnell

The year 1965 was the wettest year in the history of the Rosemount Soils Farm. From April 1 to September 30 there was a total of 29.48 inches. Along with this large amount of rainfall the intensities were very high. For example, on June 1 there was a total of 2.10 inches. Of this total .95 of an inch came in 40 minutes in 3 intensity periods. In one 10 minute period there was .35 of an inch, in another 20 minute period there was .35 of an inch and in another 10 minute period there was .25 of an inch. With such intensities erosion was severe on some fields where grassed waterways were not necessary until this year. On May 27 there was a very damaging frost to the corn on the lower fields. On July 8 there was a severe wind storm that was clocked at 90 miles per hour that caused considerable damage to the corn and small grain plots. With these extreme seasonal and weather conditions coupled with lower than normal temperatures these weather stresses brought out the importance and necessity of good land use, crop rotation systems and response to the different fertilizer treatments. All crops were delayed in planting because of the extremely wet conditions. Almost 8.0 inches of precipitation came during May and June.

### Beef Production from Fertilized Renovated and Fertilized Grass Pastures
### 1965

P. M. Burson, Soils; A. R. Schmid, Agronomy;
A. L. Harvey and J. C. Meiske, Animal Husbandry

Four types of pasture treatments, replicated twice, were compared on the G series. The treatments consisted of grass with no fertilizer, grass with 8 tons of manure per acre applied in the fall, 80 lbs. of actual nitrogen applied in the spring plus 200 lbs. of 0-20-20 applied annually and renovated

pastures with the same annual application of 0-20-20. Until 1965 all pastures except the control received the annual treatment of 200 lbs. of 0-20-20 as based on soil test. In 1965 no 0-20-20 was applied on the manured pastures because of the very high soil test for phosphate and potash. The 80 lbs. of actual nitrogen was applied in single and split applications. In one combination the nitrogen was apllied about May 1 as compared to all being applied about June 10. Two other combinations were compared with one-half the rate applied about May 1 and the remaining one-half about July 1. This was compared to still another combination of nitrogen treatments with one-half applied about June 10 and the remaining one-half about July 1. Split application has not been as effective but the early June application has been the best. At this period the early normal and rapid spring growth has been grazed off. Then the June application may extend the effectiveness of the nitrogen treatments.

All pastures were limed in the fall of 1956 with 3 tons per acre of ground limestone. The two renovated pastures were cultivated three times in the fall, and one time in the spring with a deep tiller. All tillage operations were on the contour of the slope. Then it was disked and seeded to a mixture of vernal alfalfa at 5 lbs. per acre, alsike clover at 1 lb. per acre, Lincoln bromegrass at 6 lbs. per acre and Orchard grass at 2 lbs. per acre.

Results and Discussion

Grazing started May 11 using "common to medium" Holstein steers. Grazing was terminated September 8. The three improved pastures (manure, commercial fertilizer and renovation) were superior to the control pastures in beef produced per acre, value of beef produced per acre and the number of steer days per acre, as shown in Table 1 . The value of beef produced per acre over lime, fertilizer, tillage and seed costs was highest for the nitrogen at $49.64 per acre, followed by renovation at $45.01 per acre, manure at $35.05 per acre and the control at $33.60 per acre. For an average of 4 years

the renovated and the nitrogen pastures produced about the same return followed by the manure and the control last. In 1965 the greatest return per acre in terms of beef produced was $16.00 from the use of 80 lbs. of N on grass after lime and fertilizer changes had been deducted. The response of the manure treatment and the nitrogen treatments are usually about the same from year to year but in 1965 the manure treatment was not much better than the control. This was caused be some sick steer that did not gain and for some time had to be kept off the pasture for medical treatment.

Table 1. Beef produced from brome-timothy on renovated pasture rotational grazing). May 11 to September 8, 1965 (120 days).

| Treatment<br>Pasture No. | | Control<br>(G4,G6) | Manure[a]<br>(G1,G7) | Nitrogen[b]<br>(G2, G5) | Renovated[c]<br>(G3, G8) |
|---|---|---|---|---|---|
| No. acres | | 3.2 | 3.2 | 3.0 | 3.4 |
| No. steers at start | | 4 | 6 | 6 | 6 |
| Av. initial wt., lb. | | 529 | 524 | 525 | 523 |
| No. steers at finish | | 4 | 5 | 5 | 5 |
| Av. final wt., lb. | | 681 | 652 | 684 | 675 |
| Total gain, lb. | | 600 | 741 | 999 | 910 |
| Av. daily gain, lb. | | 1.35 | 1.18 | 1.68 | 1.52 |
| Total no. steer days | | 444 | 627 | 594 | 598 |
| Steer days/acre | | 138 | 195 | 198 | 176 |
| Beef produced/acre | | 187 | 231 | 333 | 297 |
| Value of beef produced/acre @$18.50 cwt. (est.) | | $34.60 | $42.74 | $61.61 | $56.90 |
| Fertilizer, lime, and manure cost/acre | | 0.97 | 7.69 | 11.97 | 5.25 |
| Tillage and seed cost | | | | | 6.64 |
| Value of beef produced/acre less lime, fertilizer, tillage and seed costs | 1965 | $33.63 | $35.05 | $49.64 | $45.01 |
| | 1964 | 37.04 | 59.01 | 54.81 | 49.22 |
| | 1963 | 42.95 | 57.69 | 67.95 | 70.19 |
| | 1962 | 49.90 | 66.05 | 63.00 | 68.01 |
| | Ave. | 40.67 | 54.45 | 58.85 | 58.10 |

All steers were implanted with stilbestrol May 11. Lime--all pastures @ 3 tons per acre, cost $0.97 per year over 10 year period.

[a]Manure, 8 tons per acre annually (fall), value $9.60 (charge per acre $6.72 assuming 30% carry-over).

[b]Nitrogen, 80 lbs. N/acre annually, cost $9.60 (charge per acre $6.72 assuming 30% carry-over). Also, 200 lbs./acre 0-20-20 (charge per acre $2.12 assuming 9¢ lb. for P, 7¢ lb. for K and 20 and 50% carry-over, respectively.

[c]Renovated 1960-61, four workings with a deep tiller and once with disk, cost at $2 per operation per acre $15 or $5 per year over 3 years. Also, same amount of 0-20 as on N pasture. Seed was Vernal alfalfa 5 lbs./acre,alsike 1, Lincoln brome-grass orchardgrass 2; cost $4.92 or $1.64 per year over a 3 year period.

# BEEF PRODUCTION FROM LENIENTLY GRAZED ALFALFA-GRASS PASTURE GRAZED THROUGHOUT THE SEASON versus MODERATELY GRAZED ALFALFA-GRASS SUPPLEMENTED WITH PIPER SUDAN PASTURE

A. R. Schmid, Agronomy; P. M. Burson, Soils, A. L. Harvey and J. C. Meiske, Animal Husbandry

This experiment was started this year to answer the question should one graze alfalfa-grass pasture leniently and throughout the season or would it be bette to graze it moderately heavy, and then when its production is down in July and August to supplement it with sudangrass pasture.

Two alfalfa-grass pastures, one seeded in 1963 (D pasture) and one in 1961 (E pasture), were divided to form 8 pastures of 1.875 acres each. Each pair of treatments (lenient versus moderate with sudan) was arranged on a part of the pasture having the same fertilization and cropping history (4 pairs or replications). Sudan was provided in two 3 acre pastures (field 47). These two pastures had previously been in alfalfa and were plowed in June of 1965 prior to seeding. Because of the late wet spring the Piper sudan (30 lb. per acre) was not seeded until June 8 on the north part and June 11 on the south part of field 47. Then the cool weather slowed the growth so that the first grazing was not started until July 19.

Holstein steers with an average weight of 513.7 lbs. were placed on the treatments starting with the alfalfa-grass on May 21 (see Table 1). The 7.5 acres for lenient grazing (4 pastures 1.875 acres each) were allotted 16 animals (4 per pasture) and the 7.5 acres for moderate grazing 28 animals (7 per 1.875 acre pasture). Assuming that each steer represented 2/3 of an animal unit this amounted to 0.69 animal unit per acre on the lenient and 1.24 on the moderate for the period they were grazed. The sudan stocking rate was 3.11 for the period it was grazed. The combined alfalfa-grass plus sudan figured out to .89 animal units per acre for the entire season.

Results and Discussion

As shown in Table 1, the average daily gain per animal ranged from 1.89 to 2.09 lbs. Because of the lower stocking rate and favorable weather, at no time were the steers on lenient grazing short of pasture. On the moderately grazed treatment plus sudan no grazing was available from July 29 to August 17. During this time these animals were kept on an alfalfa-grass holding pasture. Sudan provided pasture only from July 19 to 29 and September 1 to 8. Better performance of the sudan (with earlier seeding and warmer weather) might have filled the gap. As a result more steer days per acre and more beef per acre were obtained from the leniently grazed alfalfa-grass than from the alfalfa-grass and sudan combined. This difference was statistically significant at the 1 percent point.

It would appear that in order to have sudan pasture pay as a supplement to alfalfa-grass it would have to be productive and provide pasture shortly after the 4th of July. The annual cost of seed, nitrogen fertilizer, plowing, discing and seeding increases the cost per acre over alfalfa-grass. This is reflected in the larger returns per acre of $77.38 for the leniently grazed as compared to the $51.43 for the moderately grazed alfalfa-grass and sudan combined. More years of work on this comparison are needed to come to firm conclusions.

Table 1. Beef produced from alfalfa-grass pasture leniently grazed throughout the season versus alfalfa-grass moderately grazed and supplemented with Piper sudan pasture (4 replications of alfalfa-grass).

| | Alfalfa-grass[a] only | Alfalfa-grass plus sudan | | |
|---|---|---|---|---|
| | | Alfalfa-grass | sudan[b] | combined[c] |
| No. acres | 7.5 | 7.5 | 6 | 13.5 |
| No. steers at start | 16 | 28 | | |
| No. days on pasture | 110 | 74 | 17 | 91 |
| Stocking rate/acre in A.U. | .69 (season) | 1.24 (period) | 3.11 (period) | .89 (season) |
| Av. initial wt. lb. | 514.1 | | | 513.4 |
| Av. final wt.,lb. | 743.8 | | | 720.4 |
| Total gain, lb. | 3631 | 3818 | 939 | 4757 |
| Av. daily gain lb. | 2.09[n.s.] | 1.86 | 2.00 | 1.88 |
| Total no. steer days | 1738 | 2057 | 469 | 2526 |
| Steer days/acre lb. | 231.7 | 274.2 | 78.2 | 187.1 |
| Beef produced/acre lb. | 484.2** | 509.1 | 156.5 | 352.4 |
| Value of beef produced/acre@ $18.50 cwt. (est.) | $89.58 | $94.18 | $28.95 | $65.19 |
| Fertilizer, lime, tillage, seed and salt cost/acre[e] | $12.20 | $12.32 | $18.34 | $13.76 |
| Value of beef produced/acre less lime, fertilizer, tillage, seed and salt costs | $77.38 | $81.86 | $10.61 | $51.43 |

[a]Mixture - V. alf. 5, alsike 1, L. brome 6 orch. G.2 (2 reps. on "D" 1963 seeding and 2 on "E" 1961 seeding)
[b]Sudan drilled at 30#/acre on 6/8-11 and grazed 7/19-29 and 9/1-8
[c]Cattle off alf.-grass-sudan experiment from 7/29 to 8/17
[d]Each steer figured as 2/3 of animal unit (A.U.)
[e]Alfalfa-grass pasture costs - 200 lbs/acre 0-20-20 (charge 4.28/acre assuming 9¢ lb. for P, 7¢ lb. for K and 20 and 50% carryover respectively). Tillage and seeding $6.64 per year ($19.92 spread over 3 years). Lime 3 tons per acre $.97/acre ($9.70 spread over 10 years).
Sudan costs - seed $5.10, lime $.97, plow and disc $4.00, 60# N $7.20 (alfalfa plowed under assumed to contribute 60#N).
n.s.Not significantly different from the 1.88 for the combined.
**Significantly different (1% level) from the 352.4 for the combined

# Nitrogen Fertilization of Oats Seeded to Alfalfa 1965

Paul M. Burson and E. G. Bonnell

Five rates of dry nitrogen fertilizer was applied to the Dodge Variety of oats at planting time. The rates were 20, 30, 40, 60 and 80 lbs. of actual nitrogen per acre. This was conducted on two fields with one in soybeans and the other in corn in 1965. These two fields had been in a fertilized corn and soybean cropping system since 1959. The results are as follows:

| | Bu. yield per acre | |
|---|---|---|
| Lbs. of N per acre | Following corn | Following soybeans |
| check | 65.9 | 48.7 |
| 20 | 72.5 | 68.7 |
| 30 | 65.6 | 58.7 |
| 40 | 55.0 | 60.0 |
| 60 | 43.7 | 56.2 |
| 80 | 37.5 | 52.5 |

The early season growth including emergence was best on the higher rates of nitrogen of 30 lbs. or more. Later in the season lodging began to occur especially following the heavy wind and rain storm on July 8. Lodging was progressively worse on all rates from 30 lbs. of nitrogen per acre and higher. At the same time yields per acre went down as lodging became worse. Very little lodging occurred on the 20 lb. rate of nitrogen per acre. However, the oat yield for all nitrogen treatments was 4.3 bu. more per acre following soybeans as compared to following corn.

On five other fields in rotation with corn, soybeans and alfalfa, 30 lbs. of nitrogen per acre was applied at seeding time. Oats were seeded at 1 1/2 bu. per acre and Vernal alfalfa at 20 lbs. per acre. There were three treatments which included check, residual carry-over of starter and sidedressed nitrogen on

starter and sidedressed nitrogen on the corn and the residual starter fertilization for corn plus the 30 lbs. of nitrogen applied in 1965 on the oats seeded to alfalfa. The check has never received fertilizer. The average results for the five fields are as follows:

Bu. Yield per acre

| check | Residual Fertilizer | Residual fertilizer and 30 lbs. N per acre |
|---|---|---|
| 57.6 | 67.9 | 84.3 |

The residual fertilizer gave an increase of 10.3 bu. over the check while the additional 30 lbs. of nitrogen and residual gave 16.4 bu. increase over the residual. There was lodging on all fields when the nitrogen was applied. No lodging occurred on the check and residual. It was interesting to note that there was about double the growth of the newly seeded alfalfa with the 30 lbs. of nitrogen over the residual and check treatments. This difference continued until after June 15. Probably the reason for this early spring alfalfa growth difference on the nitrogen treatment was the cool wet season, especially during the early part. However, the increase in yield was 16.4 bu. for 30 lbs. of nitrogen or it took slightly less than 2 lbs. of nitrogen for each bu. increase in yield.

Corn in Rotation vs Continuous Corn
with Fertilizer
1965

Paul M. Burson and E. G. Bonnell

On twelve different fields trials were run to compare the difference between corn yields following alfalfa in a rotation with continuous corn yields on fields having been in continuous corn since 1957. Some fields had been in continuous corn since 1952. All fields had starter fertilizer according to the soil test. On the areas using nitrogen fertilizer as a sidedressing, at the first cultivation, the continuous corn received 100 lbs. of actual N while the corn in rotation received 66 lbs. of actual N per acre.

The check areas on each field have never been fertilized during the history of the soils farm. The average yield results are as follows:

| Fertilizer Treatments | Continuous Corn | Rotation Corn | Increase for Rotation |
|---|---|---|---|
| check | 53.6 | 95.5 | 41.9 |
| Starter | 84.8 | 112.7 | 27.9 |
| Starter + N | 120.7 | 125.0 | 4.3 |

These yields show the difference in landuse and fertilizer response in a year of great seasonal stress as was true of the cool wet season which prevailed throughout 1965. In such a season as 1965 nitrogen was most important in corn production. This is shown by nitrogen fertilizer response on continuous corn as compared to the nitrogen contributed by the alfalfa in the rotation system. There was an increase of 35.9 bu. for starter and nitrogen over starter with continuous corn as compared to 12.3 bu. increase for starter and nitrogen as compared to starter alone with corn in rotation. The starter fertilizer was 250 lbs. per acre of 4-12-24.

## Soybean Fertilization and Row Spacing 1965

Paul M. Burson and E. G. Bonnell

The 1965 soybean feilds were very erratic. Growth was very poor until about July 25, regardless of soil treatments. During this 1965 early period, growth was very slow, leaves were spotted and generally light green and yellow in color. By August 1 they had made complete recovery but were so delayed that yields were below the normal production and maturity was very late. Even though the overall yields were much lower, the fertilization did improve the speed of maturity so the front damage was at a minimum. The beans were small in size but were of generally good quality.

On 5 fields the checks averaged 20.6 bu. per acre, residual corn starter from the previous year was 23.3 bu. per acre while 250 lbs. of 4-12-24 as band

starter averaged 26.0 bu. per acre. On one of the fields, 33 lbs. of nitrogen was sidedressed at the first cultivation and the yield was 28.3 bu. per acre. When 66 lbs. of nitrogen was applied the yield was down to 26.6 bu. per acre.

On another field strip a fertilized row spacing trial was conducted using 250 lbs. of 4-12-24 in 38, 30 and 7 inch rows. No difference was noted in fertilizer response as compared with the check. This was probably the result of a previous fertilizer history. The yields were progressively lower as the rows became narrower. The 38 inch rows produced 28.3 bu. per acre, 30 inch rows 25.0 bu. and the 7 inch drilled rows 16.6 bu. per acre. As the rows became narrower the lodging became more serious with no lodging on the 38 inch rows. with severe lodging on the 7 inch rows.

## Lime and Fertilizer on Continuous Corn
## 1965

Paul M. Burson and E. G. Bonnell

Manure, lime and starter fertilizer on 13 years of continuous corn was the best combination of soil treatments for the wet cool weather conditions in 1965. Lime was applied in December, 1961 at the rate of 3 tons per acre according to soil test. Manure is applied annually at the rate of 10 tons per acre and plowed under. The starter fertilizer 6-24-12 was placed in a band at 175 lbs. per acre according to soil test. The soil types are Judson and Clyde silty clay loams. The 1965 yield results are as follows:

| Soil treatments | Bu. yield per acre |
|---|---|
| 1. Check | 111.0 |
| 2. Manure | 128.0 |
| 3. Manure + lime | 137.0 |
| 4. Manure + starter | 135.5 |
| 5. Manure + lime + starter | 140.0 |

On another field which was mainly a Port Byron silt loam, upland soil, which had been in continuous corn for 8 years but no manure had been applied. Nitrogen was sidedressed at the first cultivation at the rate of 100 lbs. per acre.

This field was limed in November 1964 at 3 tons per acre according to soil test. The results are as follows:

| Soil treatments | Bu. Yield per acre |
|---|---|
| 1. No lime | 28.0 |
| 2. Lime | 44.0 |
| 3. No lime + starter(1) | 33.0 |
| 4. Lime + starter | 62.0 |
| 5. No lime + starter + N(2) | 99.0 |
| 6. Lime + starter + N | 106.0 |

(1) Starter banded 275 lbs. per acre 4-12-24.
(2) N 100 lbs. per acre sidedressed at 1st cultivation.

## Pop-up Fertilization of Corn
## 1965

Paul M. Burson, R. D. Curley and E. G. Bonnell

Pop-up fertilization is a term used to designate the placement of a small and known amount of fertilizer with the corn seed at planting time in addition to the regular banded starter application. It is thought in northern areas of the cornbelt, with a shorter growing season that a small amount of fertilizer with the seed will hasten emergence and early growth to the benefit of earlier maturity before frost danger. It is well known that to much fertilizer in contact with the seed will injury germination and reduce the stand. The same kind of planter equipment was used in 1965 as in the previous years. A herbicide applicator was used to apply the pop-up fertilizer with the seed. It was necessary to cut a larger opening in the applicator to get on a sufficient amount because of the different granulation of the fertilizer as compared to a herbicide. The 1965 trials include different combinations of fertilizer treatments in 4 replications. The starter band fertilization included 200 lbs. per acre of 8-24-12 and 300 lbs. per acre of 5-15-10. The pop-up fertilizer included the same material with the 8-24-12 at 75 lbs. per acre and the 5-15-10 at 100 lbs. per acre alone and in combination with the band starter. The amount of pop-up

fertilizer would not exceed a total of 20 lbs. of nitrogen and potash. The above rates would equal a total of 15 lbs. per acre because of a possible salt injury. No injury of stand was found. All fertilizer treatments had a range of 1500 to 2000 more plants per acre than the check. As shown in the following table starter fertilizer gave yield of 129.7 bu. per acre while starter and pop-up produced 135.3 bu. per acre or an increase of 5.6 bu. for the pop-up.

Bushel Yield per acre

| Starter | Pop-up | Starter + Pop-up |
|---|---|---|
| 129.7 | 120.7 | 135.3 |

There was a difference in maturity as shown by the earlier tosseling and earlier denting. As compared to the check, pop-up fertilizer averaged 3 to 4 days in advance of the check when there was 80% or more of tosseling, 5 days advance with starter band and 7 to 8 days with the combination of pop-up and starter.

On another field of continuous corn for 13 years pop-up gave no increase in yield but did improve maturity as indicated above. On this field the starter produced 118.0 bu. per acre while the starter + N and the starter + N + pop-up each produced 127.0 bu. per acre.

The year 1965 was an important nitrogen and potash year but mainly for the use of nitrogen. On the phosphate pop-up treatment of 100 lbs. per acre of 0-45-0.

The yield was only 101.0 bu. per acre as compared to 120.7 bu. per acre where nitrogen, phosphate and potash were used. Lodging occurred on the phosphate treatment but no lodging on the plots receiving all three nutrients. In previous years the phosphate has shown the better early response.

# Effect of Irrigation, Fertility Level and Plant Population on Corn and Alfalfa at Park Rapids, Minnesota - 1965.

E. C. Seim, A. C. Caldwell, J. Grava, E. R. Allred, W. E. Dorsey, and J. B. Swan

In 1965 a potential yield study of corn and alfalfa with supplemental irrigation was initiated on a sandy loam soil at the Park Rapids Sulfur Experimental Field. For each crop high fertility practices and high populations were compared with average management practices prevalent in the area. One-half of the plot area was irrigated on a schedule (Table 4). The other half was unirrigated. The one exception was a light irrigation of the alfalfa seeding which was necessary for the survival of the stand.

In the alfalfa experiment, the full treatment plots received 50 lbs./A of P as 0- 46- 0, 300 lbs./A of K as 0- 0- 60, 5 lbs./A B as borax and 50 lbs./A of S as gypsum. The control (average management) plots received gypsum only (50 lbs./A of S). All fertilizer treatments were broadcast and worked in before planting. Ranger alfalfa was inoculated and seeded at the rate of 20 lbs./A. In late July the plots were sprayed with dalapon (2 lbs./A) to control quackgrass. On August 19, the plots were clipped about 8 inches above the ground. No yields were taken from the plots in 1965.

In the corn experiment, the full treatment plots received 150 lbs./A of N as ammonium nitrate, 25 lbs./A of P as 0- 46- 0, 200 lbs./A of K as 0- 0- 60 and 50 lbs./A of S as gypsum. Starter fertilizer, 300 lbs./A of 4- 12- 24 was applied in a band on each side of the hill. Row width was 36 inches with a hill spacing of 18 inches. Final plant population was 18,300 plants per acre. The control (average management) plots received starter fertilizer only (150 lbs./A of 4- 12- 24). Row spacing was 36 inches, hill spacing 36 inches. Final plant population was 9150 plants per acre. An 85 day corn variety, Minhybrid 805, was used in these trials.

One half of the plots was irrigated on a regular schedule. The other half received no supplemental irrigation. Rainfall measured at the experimental site is shown in table 1.

| Month | Rainfall, inches |
|---|---|
| May | 3.50 |
| June | 5.59 |
| July | 1.60 |
| August | 2.61 |
| September | 6.78 |
| Total | 20.08 |

During the period from July 13 to August 23 the only precipitation received was 1.08 in. on August 5th and 6th.

During July and August, Park Rapids received about 2.5 inches of rainfall below the average amount for the area (see table 3). The unirrigated corn was severely affected by the summer drought. The high fertility, high population corn was more seriously affected by drought than the low population, low fertility corn.

The irrigated corn grew well through the summer but its development and maturity was delayed by cool weather during August and September (Table 3). Silage yields were taken on October 2. Two weeks later (October 16) ear corn yields were obtained. Killing frost on September 26 (minimum temperature 19°F.), had stopped all growth of corn by this time. Ears were slightly dented but moisture content of the corn was very high (about 50 percent).

The yields of silage and of ear corn are shown in table 2. Irrigation and full fertility treatment nearly doubled the silage yields. Irrigated low fertility, low population plots produced 3.3 tons of silage per acre. Irrigated high fertility, high population plots averaged 6.1 tons of silage per acre. Unirrigated plots produced 2.3 tons of silage per acre with the low fertility, low population treatment and 2.5 tons per acre of silage with the high fertility and high population treatment.

Forty one bushels of ear corn per acre were harvested from the irrigated low fertility, low population plots. High fertility plus high population increased the yield to 72 bushels per acre, an increase of 31 bushels. The

yield would have been much higher if the corn had sufficient time to completely mature.

The unirrigated corn was severely damaged by a prolonged period of midsummer drought. Under those conditions the heavily fertilized, high population plots were the first to suffer from lack of moisture. Growth, pollination and maturity were so delayed that only a token yield of 12.5 Bu./A. was obtained.

Corn of the low population, low fertility plots withstood the effects of drought much better because of the reduced competition for available water and produced an average yield of 26.5 bushels of ear corn per acre.

It is evident that in a year such as 1965 irrigation meant the difference between having a crop and not having one. Climatic conditions, however, were a limiting factor for top corn production. Field corn (according to D. G. Baker and J. H. Strub, Jr. Climate of Minnesota, Technical Bul. 248. Univ. of Minn. 1965) requires a total of about 2400 growing degree days (GDD). The total GDD for the growing season of 1965 for the Park Rapids area was 1529 (table 3). The average GOD accumulated during the warm season crop period at Park Rapids is about 1766 (Baker and Strub, Jr.).

Past experience and the results obtained in 1965 would seem to indicate that crops which are more adapted to the prevalent climatic conditions in the Park Rapids area (for example potatoes) would utilize high fertility levels and supplemental irrigation better than field corn.

Table 2. Effect of Irrigation, Fertility level and population on corn at Park Rapids, Minnesota.

| Plot No. | Treatments Moisture Irrigated | Fertility | Population | Silage tons/acre | % Moisture ear corn % | Ear Corn yield Bu./acre |
|---|---|---|---|---|---|---|
| 1 | " | LF | LP | 3.36 | 51.2 | 39 |
| 2 | " | LF | LP | 3.23 | 47.9 | 43 |
| | | Averages | | 3.30 | 49.5 | 41 |
| 2 | Irrigated | HF | HP | 6.27 | 53.1 | 75 |
| 4 | " | HF | HP | 5.93 | 51.5 | 69 |
| | | Averages | | 6.10 | 52.3 | 72 |
| 1 | Non-irrigated | LF | LP | 2.37 | 43.8 | 32 |
| 3 | " | LF | LP | 2.26 | 43.4 | 21 |
| | | Averages | | 2.31 | 43.6 | 26.5 |
| 2 | Non-irrigated | HF | HP | 2.47 | 66.6 | 9 |
| 4 | " | HF | HP | 2.52 | 58.5 | 16 |
| | | Averages | | 2.50 | 62.5 | 12.5 |

Low fertility plots received 150#/acre of 4-12-24 starter
High fertility plots received 150#/acre N
25#/acre P Broadcast
200 #/acre K
300 #/acre of 4-12-24 starter
Low population level - 9,150 plants/acre

Table 3. Rainfall and Temperature Data for the Growing Season of 1965, Park Rapids Weather Station*

| Month | Rainfall (inches) Total | Rainfall (inches) Departure from normal | Temperature (°F) Average | Temperature (°F) Departure from normal | Growing degree Days (GDD) Base Temperature = 50°F. |
|---|---|---|---|---|---|
| May | 4.35 | 0.80 | 54.8 | 1.6 | 50 |
| June | 6.57 | 2.62 | 63.1 | 0.2 | 393 |
| July | 2.00 | -1.50 | 66.8 | - 2.4 | 521 |
| August | 2.93 | -1.10 | 66.0 | - 0.7 | 496 |
| September | 6.20 | 4.16 | 48.8 | - 7.3 | 69 |
| Total | 22.05 | 4.98 | | | 1529 |
| Average | | | 59.9 | - 8.6 | |

*From Climatological Data, Minnesota, Wol. 71, 1965. U. S. Weather Bureau.

Table 4. Date, Duration and Rate of Supplemental Irrigation on the Corn and Alfalfa High Potential Plots, Park Rapids - 1965.

| Date | Hours | Amount Applied (inches) |
|---|---|---|
| June 16 | 2.0 | 1.00 |
| " 24 | 4.0 | 2.00 |
| July 7 | 3.0 | 1.50 |
| " 19 | 3.0 | 1.50 |
| " 26 | 4.5 | 2.25 |
| August 4 | 4.5 | 2.25 |
| " 14 | 4.5 | 2.25 |
| " 22 | 4.5 | 2.25 |
| TOTAL | 30.0 | 15.0 |

Table 5. Effect of Fertilization and Supplemental Irrigation on the Chemical Composition of Sixth Corn Leaf at Silking Time, Park Rapids. 1965.

| Treatment | K % | P % | Ca % | Mg % | Mn ppm | Fe ppm | B ppm | Cu ppm | Zn ppm | Mo ppm | Co ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Low fertility, irrigated | 1.34 | .32 | .91 | .34 | 64 | 1192 | 5 | 10 | 24 | 1.14 | .54 |
| Low fertility, non-irrigated | 1.42 | .32 | .88 | .28 | 70 | 174 | 6 | 15 | 28 | 1.35 | .29 |
| High fertility, irrigated | 1.77 | .29 | .71 | .20 | 71 | 993 | 5 | 10 | 20 | .58 | .34 |
| High fertility, non-irrigated | 2.10 | .29 | .84 | .27 | 80 | 153 | 5 | 12 | 24 | .91 | .40 |


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# The Effect of Urea or Ammonium Nitrate Nitrogen on the Nitrate Nitrogen Content of Webster clay loam surface soil and Different Portions of Growing Corn Plants at Lamberton in 1964 & 1965

J. M. MacGregor and W. W. Nelson

Many farmers have become concerned with the effect of nitrogen fertilization on the nitrate content of corn plants during the growing season, especially where growth is retarded by dry soil conditions at some period of growth. Research in several mid-western states has shown that drowth conditions result in marked increases in the nitrate content of corn. Olson (1) stated that forages and silages containing less than 0.15% of nitrate nitrogen appear safe to feed, feeds containing 0.15% to 0.40% nitrate nitrogen should be supplemented to supply a ration averaging less than 0.15% nitrate nitrogen, whereas those forages containing over 0.45% nitrate nitrogen are potentially dangerous to feed, even at restricted levels. He concluded that nitrate poisoning of livestock is relatively rare, and that fertilizer practices should be based on Experiment Station recommendations without concern for the possibility of nitrate poisoning.

A long term nitrogen fertilizer experiment has been in progress at the Southwest Experiment Station at Lamberton on a Webster soil planted to continuous corn beginning with the 1960 growing season. Nitrogen has been annually applied at rates of 40, 80 or 160 pounds per acre either as ammonium nitrate or as urea for six years.

In 1964 corn plants were randomly sampled from two replications on each of five different nitrogen treatments in mid-June mid-July, mid-August, and finally in mid-September. Soil samples were also taken at the same times at the six-inch depth immediately adjacent to the corn roots. The corn plants were immediately chilled following sampling, and dried in a circulating air oven at 55°C. After drying, the tissues were separated into leaves, upper stalks and lower stalks (with the exception of the mid-June sampling which consisted entirely of leaves). The soil samples were also chilled and all samples were then analysed for nitrate content.

The entire sampling and analytical procedure was repeated in 1965, but since the corn was not planted until early June, the sampling of soil and leaf tissue for that month was omitted.

The nitrate values obtained on all samples are shown in the following table. The tissue samples considered to be at toxic levels for uncontrolled animal feeding by Olson's nitrate values are identified with the symbol 't'.

The nitrate content of the soil was directly related to the amounts of fertilizer nitrogen applied over the five and six year period, with the relatively large amounts present in mid-June of 1964 or mid-July,1965 rapidly decreasing as the growing season progressed.

Nitrate levels of the corn leaves sampled in mid-June were relatively high, and as the rates of nitrogen applied increased, toxic nitrate levels were consistently present. By mid-July 1964, however, nitrate levels of the leaves were and remained at relatively low levels for the remainder of the growing season. Because of the later 1965 planting, the July tissues contained toxic levels in July 1965.

Upper stalks, which were not available for the June 1964 sampling, could be considered relatively safe for feeding during the three months in which these were analyze In 1965, all fertilized upper stalks contained toxic amounts of nitrate nitrogen.

However, in the lower stalks, tissues growing on the plots (1964) receiving no nitrogen, had relatively low concentrations, but as rate of nitrogen fertilization increased (especially in July with relatively high soil nitrate levels) these tissues consistently contained toxic nitrate concentrations which decreased as the growing season progressed. The nitrate content of lower corn stalks sampled in August and September were relatively safe for feeding where nitrogen was applied annually at the 80 pound per acre rate. However, when this N fertilization rate was doubled to an annual application rate of 160 pounds per acre, the lower corn stalks contained toxic nitrate levels through the entire growing season.

Nitrate Nitrogen Concentrations in 1964 and 1965 Corn Plants on Webster Clay Loam at Lamberton Fertilized Annually with Ammonium Nitrate or Urea
(Average of 2 replicates)

| Lbs N/A annually | Avg. Soil Nitrate-N in ppm | | | | Percentage nitrate nitrogen in corn tissues | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Leaves | | | | Upper stalks | | | Lower stalks | | |
| | June | July | August | Sept. | June | July | August | Sept. | July | August | Sept. | July | August | Sept. |
| check | | | | | | | | | | | | | | |
| 1964 | 5 | 2 | 1 | 1 | 0.28 | 0.03 | 0.03 | 0.02 | 0.06 | 0.04 | 0.02 | 0.03 | 0.03 | 0.01 |
| 1965 | = | 6 | 5 | 6 | -- | 0.25 | 0.03 | 0.02 | 0.63 | 0.02 | 0.03 | 0.92 | 0.03 | 0.02 |
| 80/A $NH_4NO_3$-N (spring) | | | | | | | | | | | | | | |
| 1964 | 19 | 5 | 3 | 2 | 0.47 | 0.06 | 0.04 | 0.02s | 0.24 | 0.07 | 0.02 | 0.72 | 0.16 | 0.05 |
| 1965 | - | 29 | 18 | 8 | -- | 0.29 | 0.04 | 0.02 | 0.72 | 0.04 | 0.02 | 1.20 | 0.11 | 0.03 |
| 80/A Urea-N (spring) | | | | | | | | | | | | | | |
| 1964 | 23 | 4 | 4 | 2 | 0.44 | 0.05 | 0.04 | 0.03 | 0.25 | 0.06 | 0.03 | 0.42 | 0.30 | 0.17 |
| 1965 | - | 12 | 20 | 7 | -- | 0.33 | 0.01 | 0.03 | 0.92 | 0.02 | 0.02 | 0.81 | 0.07 | 0.02 |
| 160/A $NH_4NO_3$-N (fall) | | | | | | | | | | | | | | |
| 1964 | 46 | 33 | 6 | 4 | 0.60 | 0.11 | 0.04 | 0.02 | 0.39 | 0.16 | 0.08 | 0.80 | 0.82 | 0.53 |
| 1965 | - | 9 | 5 | 8 | -- | 0.76 | 0.03 | 0.03 | 0.77 | 0.07 | 0.02 | 1.12 | 0.25 | 0.21 |
| 160/A Urea-N (fall) | | | | | | | | | | | | | | |
| 1964 | 36 | 6 | 6 | 2 | 0.58 | 0.14 | 0.07 | 0.01 | 0.43 | 0.12 | 0.03 | 0.67 | 0.76 | 0.38 |
| 1965 | - | 12 | 7 | 16 | -- | 0.26 | 0.04 | 0.04 | 0.75 | 0.09 | 0.05 | 1.02 | 0.60 | 0.69 |

t = values exceeding 0.44% $NO_3$-N are considered to contain toxic concentrations for animal feeding, even in limited quantities.

In the July 1965 sampling, the lower stalks of even the unfertilized corn contained toxic concentrations.

This illustrates that heavy nitrogen fertilization and stage of corn growth results in abundant soil nitrate and toxic nitrate levels in some corn tissues grown under the conditions in 1964 and 1965. It is probable that either legume ground or soils receiving heavy applications of barnyard manure would result in similar trends, but of lower magnitude. Nitrate nitrogen concentrations present in June, 1964 corn, and in mid July, 1965 corn show that growth stage probably has a more important effect on nitrate nitrogen concentrations in corn tissue than N application rates.

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(1)Olson, Oscar: Nitrate Problems in Livestock Feeds. Report of the Fourteenth Annual Soils and Fertilizer Short Course. Leamington Hotel, Mpls, Minn., November 23-24

# The effect of nitrogen source, placement and time of application on the yield of continuous and corn soil nitrate content of Webster clay loam at Lamberton in 1965

J. M. MacGregor and W. W. Nelson

The effect of fertilizer nitrogen, either as ammonium nitrate or as urea, on corn yield has been studied for the past six years. Previous reports have also included the nitrogen present in the corn plants, but this was not done in 1965.

From 1960 through 1965, uniform but ample amounts of P and K fertilizer have been applied to all plots. Varying amounts and kinds of nitrogen have been applied either before or after plowing in the fall, at time of seeding, or as a late June sidedressing. April and May of 1965 were excessively wet with rainfall of 4.60" and 6.87", with a relatively normally drier four months following. Planting was delayed until June since soil sampling to a 96" depth were desired, but these were not obtainable until August. A relatively cool summer further delayed corn growth and an earlier than normal frost in September resulted in a lower than normal yield. The 1965 ear corn yields are shown in the following table in order of decreasing yields. All of the plots are fall plowed.

Table 1. The effect of nitrogen source, rate of application and time of application to Webster clay loam at Lamberton on the sixth year yield of ear corn in 1965.

(Average of four replicates)

| Treatment # | Time & method of N application (N in lbs./A) | Avg. yield of ear corn (Bu./A) | Significance[a] |
|---|---|---|---|
| 13 | 80 urea-N at planting | 84.4 | a |
| 18 | 160 $NH_4NO_3$-N as sidedressing | 77.6 | ab |
| 12 | 80 $NH_4NO_3$-N at planting | 74.2 | abe |
| 9 | 160 urea-N plowed down in fall | 73.5 | abcd |
| 7 | 80 urea-N " " " " | 73.0 | abcd |
| 8 | 160 $NH_4NO_3$-N " " " " | 70.8 | bcde |
| 16 | 80 $NH_4NO_3$-N as sidedressing | 68.1 | bcde |
| 17 | 80 urea-N " " | 64.7 | bcde |
| 6 | 80 $NH_4NO_3$-N plowed down in fall | 63.4 | bcdef |
| 10 | 40 $NH_4NO_3$-N at planting | 63.4 | bcdef |
| 11 | 40 urea-N " " | 59.8 | cdefg |
| 5 | 40 urea-N on top of plowing in fall | 57.4 | defg |
| 14 | 40 $NH_4NO_3$-N as sidedressing | 54.8 | efg |
| 15 | 40 urea-N " " | 48.4 | fgh |
| 4 | 40 $NH_4NO_3$-N on top of plowing in fall | 45.6 | ghi |
| 3 | 40 urea-N - plowed down in fall | 38.8 | hi |
| 2 | 40 $NH_4NO_3$-N - " " " " | 34.9 | hi |
| 1 | check - no N | 33.1 | i |

[a]According to Duncan's Multiple Range Test, those yields with similar letters are not mathematically different at the 5% level.

The heavy rains of early spring lowered the efficiency of fall applied fertilizer and in general, nitrogen applied at planting in the spring was most efficient, followed by late sidedressed N treatments, then N fertilizer left over winter on the plowed surface, with the fall plowed under nitrogen being the least effective of the four treatments for increasing corn yields. With the heavy April-May rains, the later and more shallow N applications were more effective.

A second approach would be a study of the total 6 year (1960-65) ear corn yield with the different N application over this period as shown in the following table:

Table 2. Total six year ear corn yield, increas e and pounds of N applied to a Webster silty clay loam at Lamberton.

| Rank | Treatment (lbs. N/A) | Total Bu/A | 6 yr. average | N applied in 6 yr. |
|---|---|---|---|---|
| 1 | 160 urea plowed down in fall | 574.1 | 95.7 | 960 |
| 2 | 80 $NH_4NO_3$ - late sidedressing | 567.3 | 94.6 | 480 |
| 3 | 160 $NH_4NO_3$ - " " | 554.6 | 92.4 | 960 |
| 4 | 80 urea - at planting | 546.7 | 91.1 | 480 |
| 5 | 80 urea - late sidedressing | 541.4 | 90.2 | 480 |
| 6 | 160 $NH_4NO_3$ - plowed down in fall | 533.8 | 89.0 | 960 |
| 7 | 80 $NH_4NO_3$ - " " " " | 522.7 | 87.1 | 480 |
| 8 | 40 $NH_4NO_3$ - at planting | 519.0 | 86.5 | 240 |
| 9 | 80 $NH_4NO_3$ - " " | 507.9 | 84.7 | 480 |
| 10 | 80 ureas - plowed down in fall | 507.7 | 84.6 | 480 |
| 11 | 40 $NH_4NO_3$ - late sidedressing | 489.5 | 81.6 | 240 |
| 12 | 40 urea - top of plowing in fall | 482.8 | 80.5 | 240 |
| 13 | 40 urea - at planting | 475.9 | 79.3 | 240 |
| 14 | 40 urea - late sidedressing | 463.0 | 77.2 | 240 |
| 15 | 40 $NH_4NO_3$ - top of plowing in fall | 462.5 | 77.1 | 240 |
| 16 | 40 urea - plowed under in fall | 450.3 | 75.1 | 240 |
| 17 | 40 $NH_4NO_3$ - " " " " | 432.5 | 72.1 | 240 |
| 18 | check - no nitrogen | 402.4 | 67.1 | - |

In general, the 40 pound rate is not increasing corn yields well as the later applied N, with a maximum spread of some 14 bushels per year over the 6 years. With the 80 pounds of N per acre, there is a maximum average increase variation of 10 bushels, with the fall applied N being in general less effective. Where 160 pounds of N were applied there is an approximate 7 bushel spread between the two forms of N which is probably not significant until carried on for approximately a 10 year period.

## Soil Nitrates

Since it was obvious that much of the fertilizer N applied over the 6 year period was not being utilized by the corn crop, it was decided to determine the nitrate-N content of the soil to a depth of 96", to determine if there was an accumulation at any depth. Four replications of the (1) no nitrogen, (2) 40 $NH_4NO_3$, (6) 80-$NH_4NO_3$ and (8) 160 $NH_4NO_3$ (all plowed down each fall) were sampled by a tractor-powered hydraulic probe, frozen and analyzed late in 1965. The results are shown in Table 3.

Table 3. The effect of increasing rates of ammonium nitrate nitrogen for six years to a Webster clay loam at Lamberton on soil nitrate-nitrogen concentration under continuous corn in 1965.

(Average of four replications)

| Soil depth in inches | Check - #N (Total corn yield 402 bu.) | 40# N/A plowed down in fall 6 yr. total 240#N (Total corn yield 433 bu.) | 90# N/A plowed down in fall 6 yr. total 480#N (Total corn yield 523 bu.) | 160#N/A plowed down in fall 6 yr. total 960#N (Total corn yield 534 bu.) |
|---|---|---|---|---|
| | Pounds of nitrate nitrogen per acre | | | |
| 0-6 | 3.1 | 2.4 | 2.9 | 2.5 |
| 6-12 | 2.2 | 2.2 | 2.1 | 3.0 |
| 12-24 | 3.7 | 3.0 | 6.0 | 12.3 |
| 24-36 | 2.6 | 5.6 | 11.8 | 20.3 |
| 36-48 | 4.3 | 5.6 | 13.8 | 14.8 |
| Total in 4 feet | 15.9 | 18.8 | 36.6 | 52.9 |
| 48-60 | 5.2 | 6.6 | 11.3 | 16.9 |
| 60-72 | 6.6 | 6.8 | 10.3 | 9.0 |
| 72-84 | 6.6 | 5.7 | 7.9 | 7.1 |
| 84-96 | 6.2 | 5.2 | 6.4 | 6.3 |
| Total in 5-8 feet | 24.6 | 24.3 | 35.9 | 39.3 |
| Total $NO_3$ -N in 96" | 40.5 | 43.1 | 72.5 | 92.2 |


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It is apparent that nitrate nitrogen content under continuous corn was increased but little where 40 pounds of nitrogen was applied each fall for six years. Total corn yield over the six years increased by only 31 bushels.

Where 80 pounds of nitrogen was annually applied, total six year corn yield was increased and nitrate -N increased by 101 bushels per acre below the 12" depth. The upper 48 inches of the soil profile (generally considered the root feeding zone) contained approximately twice the nitrate nitrogen occurring under either the untreated or the 40 pound N plots. The fifth through eighth foot soil depth contained only about 50% more nitrogen than the check or the 40# N plots.

As might be expected, the application of 160 pounds of fertilizer nitrogen increased total six year yield by 132 bushels per acre and substantially increased nitrate nitrogen concentrations in the second to fifth foot of soil. However, when the entire 96 inch depth is considered, the 40 pounds of N applied annually increased total nitrate nitrogen by only 2.6 pounds per acre, the 80 pound rate by only 32 pounds, and the 160 pound rate by only 51.7 pounds per acre. All of these amounts are small in comparison to the total amounts of N applied over the six years.

Some of the nitrogen has been utilized in higher corn production, especially on the 80 and 160 pound areas. Since nitrate nitrogen content is greatest in the 12 to 60 inch depth suggests that considerable nitrate-N losses are occurring in the drainage water being removed by a tile system traversing one end of each set of plots, with consequently no marked nitrate accumulation in the subsoil which occurred on the untiled Barnes loam at Morris.

# Nitrate Nitrogen Content of a Barnes Loam at Morris in 1965 and Corn Yields after Nine Years of Continuous Corn with Varying Rates of Nitrogen Fertilization (1957-1965)

J. M. MacGregor, G. R. Blake, R. Thompson & S. Evans

In 1957 a continuous corn experiment was initiated at the West Central School and Experiment Station at Morris to study the effect of annual fertilization with different rates of fertilizer nitrogen with adequate and uniform phosphorus and potassium supplied. Plant population has varied from 16,000 to 18,000 plants per acre during the nine year period. Vegetative residues were not removed from the field with additional PK being applied at the commencement of the experiment and again in 1962.

Ear corn yields for the nine year period are shown in Table 1.

Table 1. The Effect of Annual Fall or Spring Nitrogen Topdressings on a Barnes Loam with Uniform PK on the Yield of Ear Corn From 1957 through 1965 at Morris.

| Nutrients Applied (lbs/A) | Time of Application | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 9-year Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N $PO_2O_5$ $K_2O$ | | Bushels of ear corn at 15.5% moisture | | | | | | | | | |
| 0-40-40 | spring | 65.2 | 73.2 | 36.1 | 53.3 | 32.3 | 38.1 | 62.7 | 33.2 | 50.4 | 49.4 |
| 40-40-40 | fall | 71.0 | 81.5 | 40.9 | 48.2 | 48.3 | 59.0 | 80.9 | 34.1 | 68.3 | 59.1 |
| 40-40-40 | spring | 69.4 | 81.0 | 41.5 | 55.0 | 47.6 | 62.0 | 83.5 | 29.6 | 75.3 | 60.5 |
| 80-40-40 | spring | 72.1 | 82.4 | 39.7 | 53.7 | 45.0 | 65.3 | 77.4 | 29.1 | 80.8 | 60.6 |
| 240-40-40 | spring | 71.3 | 80.3 | 36.8 | 52.5 | 46.1 | 67.1 | 79.5 | 24.7 | 82.8 | 60.1 |

The average yields over the nine year period indicate that the plots receiving no commercial nitrogen produced approximately 50 bushels of ear corn per acre, whereas the three rates of nitrogen increased yields an additional 10 bushels to approximately 60 bushels per acre irrespective of quantities of fertilizer nitrogen applied.

The comparatively low responses to relatively high rates of nitrogen application raised the question as to the fate of at least a portion of the heavier application of nitrogen.

Late in October of 1965, each of the triplicated spring applied fertilizer plots was sampled by means of a tractor operated hydraulic soil sampling tube to a depth of 8 feet (96 inches). The samples were frozen until analyzed for their nitrate nitrogen content in December. The results expressed in pounds of nitrate nitrogen per acre at the different depths are shown in Table 2. Corn roots did not penetrate below the 48 inch depth.

Table 2. Pounds of nitrate nitrogen per acre in Barnes loam after nine years of fertilizing continuous corn at Morris.

| Soil depth(inches) | Nutrient treatment in pounds per acre | | | |
|---|---|---|---|---|
| | Annually 9 yr.total | 0-40-40 0-360-360 | 40-40-40 360-360-360 | 80-40-40 720-360-360 | 240-40-40 2160-360-360 |
| | Pounds of nitrate nitrogen per acre | | | | |
| 0-6 | | 10.0 | 10.4 | 11.3 | 12.0 |
| 6-12 | | 6.1 | 9.8 | 10.4 | 13.5 |
| 12-24 | | 10.8 | 13.3 | 18.6 | 49.7 |
| 24-36 | | 8.0 | 8.1 | 32.2 | 309.2 |
| 36-48 | | 9.8 | 14.8 | 23.2 | 269.2 |
| Total in upper 48" | | 44.7 | 56.4 | 95.7 | 653.6 |
| Increase where N applied | | — | 11.7 | 51.0 | 608.9 |
| 48-60 | | 9.8 | 17.7 | 32.4 | 183.1 |
| 60-72 | | 16.6 | 15.5 | 46.7 | 208.9 |
| 72-84 | | 16.1 | 17.4 | 48.7 | 224.8 |
| 84-96 | | 18.4 | 18.4 | 38.9 | 184.7 |
| Total in 5'-8' depth | | 60.9 | 69.0 | 166.7 | 801.5 |
| Increase where N applied | | — | 8.1 | 105.8 | 740.6 |
| Lbs/A $NO_3$-N in 96" | | 105.6 | 125.4 | 262.4 | 1455.1 |
| Increase where N applied | | — | 19.8 | 156.8 | 1349.5 |
| Percentage of applied N in 0"-48" | | — | 3.3% | 7.1% | 28.2% |
| Percentage of applied N in 48-96" | | — | 2.3% | 14.7% | 34.3% |
| Percentage of applied N in 0-96" | | — | 5.6% | 21.8% | 62.5% |

The data in table 1 show that increasing rates of fertilizer N above 40 pounds per acre did not increase corn yields. Table 2 data show that in this soil which is not tiled, there is little accumulation of $NO_3$-N on the 40 pound N plots (total 360 N) above the profiles where no N was applied. In the entire 96 inch depth, there was an increase of only 19.8 lbs. of nitrate nitrogen per acre. It is probable that most of the 360 pounds of N applied over the 9 year period was utilized by the corn crop with the 10 bushel per acre increase, with only 5.6% of the applied N remaining in the soil.

Where 80 pounds of N was applied annually, the $NO_3$-N content increased markedly below the 12 inch depth. Apparently 51 pounds (7.1% of the 720 pounds applied) remained in the upper 4 feet of soil where it would be available to plants, but 105.8 pounds (14.7% of the applied 720 pounds) had been carried down to the 4 to 8 foot depth and would not be available to even the deepest corn roots. A total of 156.8 pounds of applied N remained in the 8 foot depth of soil (21.8%) of the 720 pounds applied) but about two thirds would be not available to future corn crops.

The 240 pound annual N rate resulted in a much larger $NO_3$-N concentration below the 12 inch depth, with 608.9 pounds (28.2% of that applied) in the upper 4 feet and available, and 801.5 pounds N (34.3% of that applied) in the 4 to 8 foot depth. This means that the heavy N fertilization resulted in less than a third of the N remaining available, while more than a third was essentially unavailable at the end of the nine year period, with nearly two-thirds (62.5%) of the applied nitrogen remaining in the 96 inch soil depth.

Since the 80 and 240 pound nitrogen application rates did not increase average corn yield beyond the 40 pound per acre rate, increasing rates of N application to this loam soil result in the downward movement of larger proportions, where they are unavailable to plant roots, even under the relatively low (22.6') average annual precipitation at Morris.

# FALL vs SPRING TOP DRESSING OF NITROGEN ON GRASSLANDS

Richard H. Anderson, Station Agronomist, Grand Rapids

Three replications of various levels and time of application were established on an existing bromegrass stand. Previous yields had been low although a fair plant population existed. Thus, a situation was present somewhat similar to infertile pastures. Soil test indicated following conditions:

| | |
|---|---|
| Soil Testure: | Sandy Loam |
| pH | 5.1 |
| Organic Matter: | 2.8% |
| Extractable Phosphorus: | 170 lb per acre |
| Exchangeable Potassium: | 200 lb per acre |

Treatments and plot yields as follows. (200# 0-0-60 were top dressed over entire experiment to bring K into optimum level.)

| Treatment (lbs of N) | Reps | | | |
|---|---|---|---|---|
| | I | II | III | X |
| check | 1.415 | 2.027 | 1.540 | 1.66 |
| 33.5# Fall | 2.091 | 2.287 | 1.680 | 2.02 |
| 67# Fall | 2.847 | 3.078 | 2.858 | 2.93 |
| 100# Fall | 3.286 | 3.593 | 3.701 | 3.53 |
| 33.5# Spring | 2.556 | 2.524 | 2.559 | 2.55 |
| 67# Spring | 3.430 | 3.662 | 4.106 | 3.73 |
| 100# Spring | 3.892 | 3.708 | 3.905 | 3.84 |

L.S.D. (.05) .414

ANOKA

| SOURCE | D.F. | S.S. | M.S. | F |
|---|---|---|---|---|
| Total | 20 | 13.98 | .699 | |
| Treatment | 6 | 13.19 | 2.198 | 40.7 ** |
| Reps | 2 | .14 | .07 | 1.296 N.S. |
| Error | 12 | .65 | .054 | |

Assuming $15.00 per ton value of bromegrass and $5.00 cost per 100# of Ammonium Nitrate:

| Treatment | | Yield Ton/Acre | Value of Add'l Yield | Fertilizer Cost | Value Over Cost |
|---|---|---|---|---|---|
| Check | | 1.66 | ----- | ----- | ----- |
| 33.5# | Fall | 2.02 | $ 5.40 | $ 5.00 | $ .40 |
| 33.5# | Spring | 2.55 | 13.35 | 5.00 | 8.35 |
| 67# | Fall | 2.93 | 19.05 | 10.00 | 9.05 |
| 67# | Spring | 3.73 | 31.05 | 10.00 | 21.05 |
| 100# | Fall | 3.53 | 28.05 | 15.00 | 13.05 |
| 100# | Spring | 3.84 | 32.70 | 15.00 | 17.70 |

# THE EFFECT OF NITROGEN ON THE YIELD AND PROTEIN CONTENT OF BARLEY

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In Cooperation with Dr. J. MacGregor and Dr. D. Rasmusson

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The field study this year followed the same procedure as last year with the exception that fewer treatments were used. Both plots were located on the Station and in 1964 field 17 was in potatoes and field 40 was in sugarbeets. Trophy, Larker, and Parkland were the test varieties of barley used.

## Methods

Ammonium nitrate was applied at 0, 10, and 20 lbs. of actual nitrogen per acre as a broadcast treatment and harrowed in before the plots were sown. Four other fertilizer treatments were applied in a band 2 inches away from the seed when the barley was sown. These plots were sown across the broadcast treatments and included the following:

Check

0-40-0 @ 100 lbs./acre

10-40-0 @ 100 lbs./acre

20-40-20@ 100 lbs./acre

The treatments and varieties of barley were replicated and randomized.

Protein analysis will be run under the direction of Dr. MacGregor and Dr. Rasmusson.

# THE EFFECT OF NITROGEN ON THE YIELD AND PROTEIN CONTENT OF BARLEY

Discussion: The average yield in bushels per acre and the bushel weights are given in Tables 1 and 2, respectively, for 1965.

The average yields were good for all three varieties; however, Larker gave the best response. The broadcast treatments of 10 and 20 lbs. of ammonium nitrate produced increases of 1.60 to 10.76 bushels per acre of barley when compared to the check plots.

The addition of potash did not produce any consistent increase in yield when compared to the other treatments.

There was only slight lodging on some of the plots with higher rates of nitrogen.

The soil analysis is given in Table 3.

Table 1.Average Yield of Trophy, Larker, and Parkland Barley for Both Locations - 1965

| | Rate Per Acre of Ammonium Nitrate Broadcast Before Seeding | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 10 | 20 | 0 | 10 | 20 | 0 | 10 | 20 |
| Treatment | | Trophy | | | Larker | | | Parkland | |
| Check | 60.90 | 64.34 | 62.50 | 57.52 | 67.89 | 68.28 | 64.07 | 69.47 | 69.85 |
| 0-40-0 | 62.37 | 62.56 | 68.98 | 66.57 | 68.68 | 75.50 | 63.82 | 68.28 | 70.12 |
| 10-40-0 | 69.59 | 71.03 | 67.63 | 69.59 | 78.78 | 72.35 | 62.37 | 67.50 | 71.97 |
| 20-40-20 | 63.42 | 71.95 | 71.30 | 66.57 | 71.15 | 71.69 | 62.63 | 70.12 | 68.27 |

Table 2. Average Bushel Weights for Trophy, Larker and Parkland Barley for Both Locations - 1965

| | Pounds Per Bushel | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Rate Per Acre - Ammonium Nitrate Broadcast Before Seeding | | | | | | | | |
| | 0 | 10 | 20 | 0 | 10 | 20 | 0 | 10 | 20 |
| Treatment | | Trophy | | | Larker | | | Parkland | |
| Check | 43.6 | 42.3 | 42.6 | 44.7 | 45.9 | 44.8 | 46.0 | 47.3 | 45.9 |
| 0-40-0 | 43.2 | 43.6 | 42.5 | 45.2 | 45.4 | 45.8 | 45.6 | 45.0 | 45.7 |
| 10-40-0 | 43.1 | 44.3 | 42.4 | 45.8 | 44.9 | 45.7 | 45.6 | 45.4 | 46.0 |
| 20-40-20 | 43.8 | 44.0 | 43.2 | 45.6 | 45.9 | 45.5 | 45.1 | 45.8 | 45.6 |