# Nitrogen Fertilization of Winter Oats

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This publication reports the results of an experiment designed to determine the effect of nitrogen fertilization on the yield of winter oats and to determine the effect of previous cropping systems on the response of winter oats to nitrogen fertilization. It was conducted during the four-year period, 1952-56, on the college agronomy farm at Stillwater.

The experiment was conducted during a period of below-average rainfall. The long-time average annual rainfall at Stillwater is 33.35 inches. Annual rainfall (July 1-June 30) for the four seasons concerned was as follows: 1952-53, 25.63 inches; 1953-54, 30.24 inches; 1954-55, 25.04 inches; and 1955-56, 18.91 inches. Climatic conditions were not conducive to high oat yields during this period.

The soil on the experimental site was a Kirkland silt loam (0 to 1 percent slope).** This soil has a grayish-brown silt loam surface, 6 to 10 inches thick, over a darker grayish-brown, blocky, quite compact claypan which becomes browner below about 24 inches and contains some calcium carbonate concretions. Water moves very slowly through this soil. Kirkland and related soils make up a large portion of the arable soils in north central Oklahoma.

### Darso and Oats

Previous to the establishment of this experiment, the site had been used for another experiment. During the 18-year period, 1916-1934, half the area was planted to darso each year. The other half was planted to spring oats each year for the 15-year period, 1916-1931 and to cotton for the 3-year period, 1931-1934. Both the oat and darso areas were split into plots to which different fertility treatments were applied. The seven treatments were as follows:

Treatment 1—Manure (equivalent to that which would have been produced if grain and residues had been fed to livestock) applied every 3 years.

* Respectively Soil Scientist and Agent (Soil Scientist), Soil and Water Conservation Research Division, Agricultural Research Service, jointlv employed by the U. S. Department of Agriculture and the Oklahoma Agricultural Experiment Station.

** See Appendix I for a description of a typical soil profile.

Treatment 2—Manure and rock phosphate (same as treatment 1 except 750 pounds of rock phosphate per acre every 3 years).

Treatment 3—Residues (crop residues plowed under each year).

Treatment 4—Residues and rock phosphate (crop residues plowed under each year; 750 pounds of rock phosphate applied every third year).

Treatment 5—Same as treatment 1 except only 2/3 of the manure which would have been produced if grain and residues had been fed to livestock.

Treatment 6—Same as treatment 2 except only 2/3 of the manure which would have been produced if grain and residues had been fed to livestock.

Treatment 7—Untreated.

The average manure applications were as follows:

Treatments 1 and 2 (darso system) 11 tons/A.

Treatments 5 and 6 (darso system) 9.5 tons/A.

Treatments 1 and 2 (oat system) 6.3 tons/A.

Treatments 5 and 6 (oat system) 4 tons/A.

In 1934, the fertility treatments were changed so treatments 1 and 2 received 7½ tons of manure per acre every third year and treatments 5 and 6 received 5 tons of manure per acre every third year. The rock phosphate application was reduced to 450 pounds per acre.

In 1934, the cropping system was changed on half of the area. Spring oats were grown in rotation with an annual legume (either cowpeas or mung beans) and darso was grown in rotation with hairy vetch. The legume crops were used as green manure crops. Oats and 1935. The legume crops were used as green manure crops. Oats and darso were still planted each year with the exception of 1934 and 1935, when the oat area was fallowed in 1934 and planted to cotton in 1935. The cotton and fallowing were for bindweed control. After the oats were removed, cowpeas or mungbeans were planted and then plowed under in the fall as green manure. After the darso was harvested, hairy vetch was planted and then plowed under in the spring in the preparation of the seedbed for the darso. The fertility treatments were continued on the entire area until 1952 when the old experiments were closed out.

The results of the old experiments (2) indicate that:

- An oat yield response was obtained from the application of manure previous to the initiation of the green manure variable. Six and three-tenths tons of manure per acre each three years gave an average increase of 5.3 bushels per acre per year over the untreated plot yield of 37.5 bushels per acre.

- An oat yield response was obtained from the application of manure on both the green manured and non-green manured areas. Seven and one half tons of manure per acre every three years gave an average increase of 6.4 bushels per acre per year over the untreated plot yield of 34 bushels per acre on the non-green manured area and an average increase of 4.8 bushels per acre over the untreated plot yield of 32.2 bushels per acre on the green manured area.

- The application of rock phosphate had little effect on oat yields.

- The fertility treatments did not affect darso yields previous to the initiation of the green manure variable.

- A darso grain increase of 126 pounds per acre per year for 450 pounds of rock phosphate per acre was obtained over the untreated plot of 1123 pounds of grain per acre.

- A darso grain yield response was obtained from 450 pounds of rock phosphate per acre in combination with 7½ tons of manure every three years on the green manured area, an increase of 169 pounds of darso grain per acre per year over the untreated plot average of 1123 pounds per acre.

- Manure alone had no effect on darso yields.

- Neither oat nor darso yields were increased by the green manure treatments. Average oat yields on the non-green manured and green manured treatments were 36.4 and 34.8 bushels per acre, respectively while darso yields were 1221 and 1140 pounds per acre, respectively.

This study was initiated in the fall of 1952. The nitrogen treatments were applied at right angles to the old fertility treatments. The old treatments undoubtedly affect yields but do not affect comparisons between rates of nitrogen since each nitrogen rate plot crossed all seven previous fertility treatments.

The four previous treatments on which response to nitrogen was determined in this experiment are as follows:

- Continuous darso—Darso planted each year for 36 years.
- Continuous oats—Oats or cotton planted each year for 35 years (31 years oats, 4 years cotton, 1 year fallow).
- Darso—green manure—Darso planted each year for 36 years with a vetch green manure crop plowed under each spring for the last 18 years.
- Oat—green manure—Oats or cotton planted each year for 35 years (31 years oats, 4 years cotton 1 year fallow) with a cowpea or mung bean green manure crop plowed under each fall for the last 18 years.

**Treatments:** Nitrogen rates were 0, 20, 40, 80, and 160 pounds per acre. The nitrogen rates were duplicated in randomized blocks on each previous treatment. Individual plots were 12 by 214 feet. Forkedeer winter oats were planted in the fall of 1952, 1953, and 1954 and in the spring of 1956. Nitrogen applications were made in late February or early March in 1953, 1954 and 1955. No nitrogen was applied in 1956. The crop was harvested to measure residual effect of the nitrogen treatments. The nitrogen as ammonium nitrate was broadcast on the surface of the soil with a hand-operated distributor. A blanket application of 40 pounds per acre of $P_2O_5$ was applied with the seed at planting in 1953.

The plots were harvested with a seven foot self-propelled combine. The area harvested was 7 by 196 feet.

## Results

Yields for 1953 through 1956 are presented in Tables 1 through 4. Average yields for 1953, 1954 and 1955 are shown in Figure 1.

**Table I.—Winter oat yields as affected by previous cropping treatments and nitrogen rates, 1953.**

(Average 2 replicates).

| N. | Previous Treatments | | | | |
|---|---|---|---|---|---|
| | Oats | | Darso | | |
| | Cont. | G.M. | Cont. | G.M. | Average |
| Lbs./A | | (Bu./A) | | | |
| 0 | 42.3 | 45.2 | 24.5 | 35.5 | 36.8 |
| 20 | 43.0 | 44.2 | 29.9 | 34.0 | 37.8 |
| 40 | 47.2 | 43.3 | 31.3 | 34.3 | 39.0 |
| 80 | 44.8 | 40.3 | 35.5 | 31.4 | 38.0 |
| 160 | 39.3 | 33.3 | 31.4 | 28.3 | 33.1 |
| Average | 43.3 | 41.2 | 30.5 | 32.7 | 36.9 |

In 1953, the first season after the old treatments were abandoned, the old treatment had a highly significant effect on oat yields. The most striking difference was between the old oat and darso areas. The average yield for the old darso plots was 31.6 bushels per acre, 10.7 bushels less than for the old oat plots. It is likely that the greater part of the difference was due to soil moisture. The oat area was fallowed from June until October while the final darso crop was removed in October and oats were planted as soon as a seedbed could be prepared.

Differences due to nitrogen rates were not statistically significant; however, the trend was toward increased yields with increasing nitrogen rates through 40 pounds per acre on the old continuous oat area and

**Table II.—Winter oats yields as affected by previous cropping treatments and nitrogen rates, 1954.**

(Average 2 replicates).

| N. | Previous Treatments | | | | |
|---|---|---|---|---|---|
| | Oats | | Darso | | |
| | Cont. | G.M. | Cont. | G.M. | Average |
| Lbs./A | | (Bu./A) | | | |
| 0 | 33.8 | 38.4 | 28.5 | 39.1 | 34.9 |
| 20 | 36.8 | 47.4 | 34.6 | 42.5 | 40.3 |
| 40 | 47.8 | 47.6 | 39.3 | 45.4 | 45.0 |
| 80 | 53.6 | 50.1 | 47.7 | 53.1 | 51.1 |
| 160 | 48.0 | 50.5 | 54.2 | 52.2 | 51.2 |
| Average | 44.0 | 46.8 | 40.8 | 46.4 | 44.5 |

**Table III.—Winter oat yields as affected by previous cropping treatments and nitrogen rates, 1955.**

(Average 2 replicates).

| N. | Previous Treatments | | | | |
|---|---|---|---|---|---|
| | Oats | | Darso | | |
| | Cont. | G.M. | Cont. | G.M. | Average |
| Lbs./A | | (Bu./A) | | | |
| 0 | 10.6 | 16.5 | 11.4 | 16.1 | 13.7 |
| 20 | 18.9 | 23.6 | 19.8 | 24.7 | 21.8 |
| 40 | 22.1 | 23.9 | 22.0 | 25.2 | 23.3 |
| 80 | 26.2 | 24.7 | 24.0 | 26.2 | 25.3 |
| 160 | 23.6 | 25.6 | 23.8 | 23.1 | 24.0 |
| Average | 20.3 | 22.9 | 20.2 | 23.1 | 21.6 |

through 80 pounds per acre on the old continuous darso area. On the old oat- and darso-green manured areas, the trend was toward decreasing yields with increasing rates of nitrogen. In the first season after discontinuance of the oat- and darso-green manure rotations, the soil was able to supply sufficient available nitrogen for maximum winter oat yields. It appears, however, that oats responded to nitrogen fertilization on soils that had been cropped continuously to spring oats and darso.

In the 1954 season, the second after discontinuation of the old treatments, the previous cropping history had less effect on oat yields than in the first season. There was very little difference between yields from the old oat and old darso areas. (The moisture differential of the previous season was gone.) The residual effect of the old green manure treatments was equal to 20 pounds of nitrogen on the old oat plots and 40 pounds of nitrogen on the old darso plots (Table 2). They did not, however, furnish sufficient nitrogen for maximum oat yields. Yields increased with increasing rates of nitrogen through 80 pounds per acre on all previous treatments.

In the 1955 season, the third after discontinuation of the old treatments, there was no difference between yields on the old oat and darso areas. The residual effects of the old green manure treatments were equivalent to less than 20 pounds of nitrogen (Table 3). Again the residual nitrogen from green manure on the old treatments was not sufficient for maximum oat yields. Yields increased with increasing rates of nitrogen through 80 pounds per acre on all previous treatments.

Average yields for the three-year periods are presented in Figure 1. Statistical analysis of the 3 years' data show that on the continuous oat area, yields increased with increasing rates of nitrogen through 40 pounds of nitrogen per acre. On the continuous darso area, oat yields

**Table IV.—Winter oat yields as affected by previous cropping treatments and residual nitrogen, 1956.**
(Average 2 replicates).

| N. applied in each of 3 previous years | Previous Treatments | | | | |
|---|---|---|---|---|---|
| | Oats | | Darso | | |
| | Cont. | G.M. | Cont. | G.M. | Average |
| Lbs./A | | (Bu./A) | | | |
| 0 | 9.5 | 10.3 | 12.5 | 10.7 | 10.7 |
| 20 | 9.1 | 11.2 | 13.8 | 12.3 | 11.6 |
| 40 | 11.2 | 10.3 | 14.0 | 10.5 | 11.5 |
| 80 | 12.2 | 10.1 | 13.6 | 11.4 | 11.8 |
| 160 | 10.3 | 8.2 | 10.6 | 13.0 | 10.5 |
| Average | 10.4 | 10.0 | 12.9 | 11.6 | 11.2 |

* No N applied in 1956.

increased with increasing rates of nitrogen through 80 pounds of nitrogen per acre. On the oat-green manured and darso-green manured areas, yields were increased by the application of 20 pounds of nitrogen per acre. Further additions of nitrogen on these areas did not affect yields significantly.

Yield data for 1956, in which nitrogen fertilizer was not used, are presented in Table 4. It was hoped that the residual effect of the nitrogen applied during the previous three seasons could be measured.

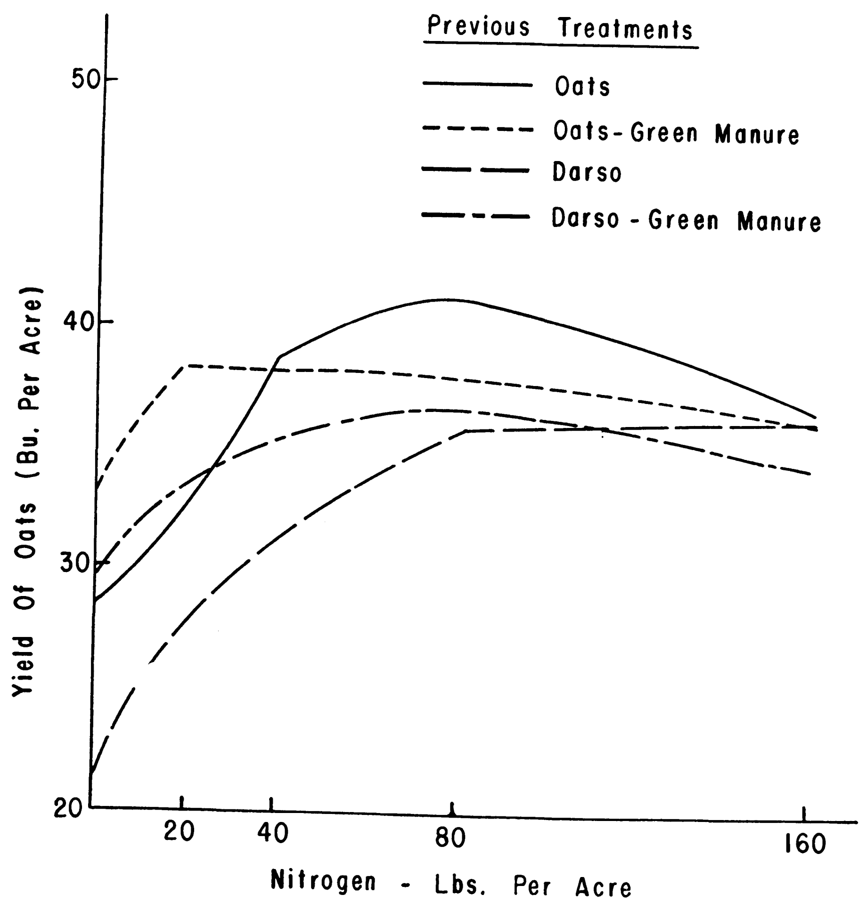


**Fig. 1.—Winter oat yields as affected by previous cropping treatments and nitrogen rates—average 1953, 1954 and 1955.**

Yields were very low due to drouth conditions, however; and there were no significant differences in yield.

## Discussion and Conclusions

The results of this experiment show that even though green manure in both an oat-green manure and a darso-green manure cropping system did not contribute to oat or darso yields during the tenure of the cropping systems, it did increase winter oat yields through the third season after the cropping systems were discontinued. Results of the old experiments indicate that the green manure did not increase oat or darso yields during the tenure of the cropping systems because the green manure crop utilized soil moisture which would otherwise have been available for the oats or darso. Moisture, rather than supply of available nitrogen, limited oat and darso yields. Murphy[1] also found this to be true in a cotton-green manure system.

The residual effects of the green manure crops decreased in succeeding seasons. While the soil furnished sufficient available nitrogen for maximum winter oat yields in the first season after green manuring was discontinued, the residual effects of the green manure were equal to less than 20 pounds of nitrogen in the third season. Since applied nitrogen increased yields to the same level on both the green manured and non-green manured areas, it may be assumed that all the green manure contributed toward oat yields was nitrogen.

Winter oats responded to nitrogen fertilization on Kirkland silt loam soils that had been cropped to spring oats or cotton for 35 years; to darso for 36 years; to an oat-green manure system for 18 years; and to a darso-green manure system for 18 years. Response to nitrogen was obtained on the oat-green manured and darso-green manured areas the second season after the old systems were discontinued.

An application of 80 pounds of nitrogen per acre was required to produce maximum winter oat yields on soil that had been cropped to darso continuously for 36 years. On the area that had been cropped to oats and cotton continuously for 35 years, the highest average yield was also produced by the 80 pound nitrogen rate; however, that yield (41.5 bushels per acre) was not statistically different from the yield produced by the 40 pound nitrogen rate (39 bushels per acre). Thus on the basis of statistical analysis, it may be concluded that 40 pounds of nitrogen per acre was sufficient to produce maximum winter oat yields on that area.

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[1] Murphy, H. F., Green Manure and Cotton in a Double-Cropping System on a Fine-Textured Soil. Oklahoma Agricultural Experiment Station Bulletin B-472, July, 1956.

# APPENDIX I

Description of Typical Kirkland Silt Loam Profile.

| | | |
|---|---|---|
| $A_1$ | 0-8 inches | Grayish-brown heavy silt loam; weak medium granular; friable; permeable; pH 5.8; a few fine pores; rests abruptly on the layer below. |
| $B_{2-1}$ | 8-22 inches | Dark grayish-brown clay; moderately fine blocky; very firm; sticky and plastic when wet; very slowly permeable; pH 7.0 at about 18 inches; sides of blocks are varnished and have strong clay films; occasional fine black concretions; grades through a 4-inch transition to the layer below. |
| $B_{2-2}$ | 22-32 inches | Grayish-brown clay; weak medium blocky; very firm and compact very slowly permeable; pH 7.5; occasional fine black pellets; a few strong brown specks about the tiny root holes; many fine $CaCO_3$ concretions below 26 inches; blocks have a weak shine when moist; grades through a 3-inch transition to the layer below. |
| $B_3$ | 32-42 inches | Brown light clay; weak medium blocky; very firm; less compact than layer above; occasional black pellets and $CaCO_3$ concretions; pH 7.5; sides of blocks have weak dark-brown coatings when moist; grades to the layer below. |
| $C_1$ | 42-52 inches | Reddish-brown silty clay loam much like layer above; occasional large $CaCO_3$ concretions with black ferruginous films; pH 7.5; grades to the layer below. |
| $C_2$ | 52-64 inches | Reddish-brown silty clay loam splotched with 10 percent of red and occasional streaks of light gray; weak blocky; firm; slowly permeable; pH 7.5; occasional fine black pellets and fine $CaCO_3$ concretions; grades to the layer below. |
| $C_3$ | 64-84+ inches | Red silty clay with occasional light-gray streaks and splotches; weak medium blocky; firm but not compact; pH 7.5+; many fine pores; material changes little to greatest depth sampled. Definite evidence is lacking but it is likely that the substratum is Pleistocene alluvium. Definite banding has been observed in deep cuts in this general vicinity. |