Border Effects on Nitrogen\textsubscript{15} Fertilized Winter Wheat Microplots Grown in the Great Plains

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ABSTRACT

Field experiments requiring $^{15}$N enriched fertilizer are costly, thus microplot techniques are generally used. Placing physical barriers around microplots to contain the $^{15}$N may introduce artifacts that affect N recovery by crops, limit types and numbers of measurements, and cause other restrictions. The purpose of this experiment was to determine minimum microplot size (without the use of barriers) for accurately measuring enriched $^{15}$N uptake into a winter wheat crop, while using normal field cultural practices. Winter wheat ($Triticum aestivum$ L.) was seeded into KNO$_3$ fertilized (56 and 112 kg N ha$^{-1}$) plots (4.57 m by 3.05 m) on a Plator silt loam (fine montmorillonitic mesic Aridic Paleustol). Within each larger plot, four microplots (2.29 m by 1.83 m) were fertilized with 10 atom % $^{15}$N enriched KNO$_3$ at the same rate as for main plots. Nitrogen-rate treatments were replicated four times in a randomized block design. Above ground plant material was harvested (0.3 m of row) from six adjacent rows at flowering (Feeke's scale = 10.5). Three rows were harvested from inside ($^{15}$N enriched KNO$_3$, added) and three from outside ($^{15}$N enriched KNO$_3$ not added) of the microplots. Plant uptake of total N into plant tops was not significantly different across any of the six harvested rows. Dry matter yields and total-N uptake were significantly larger for the 112 than for the 56 kg N ha$^{-1}$ fertilizer rate, as were the $^{15}$N uptake and atom $^{15}$N % values in plant material within the microplots. In rows adjacent to microplot borders, concentrations of $^{15}$N in plant material changed rapidly; but there were no differences beyond 0.46 m inside or outside the microplots. These results indicate that minimum microplot size for studies with fall-applied $^{15}$N on winter wheat grown in the Great Plains is 1.5 by 1.5 m.

Nitrogen tracer techniques provide a method for making quantitative measurements of N-transformation processes. In addition, tracer methods permit added fertilizer N to be distinguished from indigenous or fertilizer N. Field experiments that have utilized $^{15}$N enriched fertilizer N have varied in type from those using only single plants, through small one row plots, microplots, and lysimeters.

Because highly enriched $^{15}$N is considered too expensive for use on field plot experiments, investigators have used depleted $^{15}$N materials to measure plant recovery and movement of fertilizer-N for such experiments (Broadbent and Carlton, 1978). However, lack of isotope enrichment in depleted $^{15}$N studies usually prevents detailed examination of N-transformations, such as immobilization or mineralization. Large plots impose additional limitations such as: spatial variability; the need for large equipment and coordination of field efforts for planting, fertilizing, pest control, and harvesting; and, increased labor needs. However, much can be learned from field plots concerning the influence of environmental and soil factors on movement of N in soil, plant uptake of mineral N, the influence of tillage and residue management on organic N transformations, and gaseous N losses.

Physical barriers buried around small plots to isolate them from the surrounding soil can be used for conducting $^{15}$N field studies. The barriers, often cylinders made of steel, are driven into the soil to delineate boundaries for the small microplot. A single cylinder, approximately 30 cm in diameter pressed into the soil to a depth of 45 to 60 cm, was reported to constitute a satisfactory plot and was reliable enough to determine small changes in fertilizer $^{15}$N balance of soil (Carter, et al., 1967). This microplot procedure has many advantages. Mobile forms of N are restricted to vertical movement and lateral movement of N out of or into the experimental area is prevented. Water erosion is prevented and wind erosion is minimized. Cylinders allow test plants to absorb N only from the experimental area, and prevent tagged fertilizer from being taken up by outside plants. Well controlled conditions are provided while realistic results under field conditions are achieved (Myers and Paul, 1971).
Wheat does not possess any artifacts affecting fertilizer recovery by crops. These artifacts may result from: an inability to perform normal distribution and size, creation of artificial pores that increase aeration or movement of water and solutes, disruption of macropore systems and lateral movement of I5N occurs by mass flow or diffusion without barriers, for measuring enriched I5N was a loam in the 0- to 10-cm depth and a sandy clay loam in which temperatures may be affected by heat conducted into the soil by the steel cylinder (Olson, 1980). It is necessary to identify how artifacts affecting fertilizer recovery by crops. These artifacts may result from: an inability to perform normal distribution and size, creation of artificial pores that increase aeration or movement of water and solutes, disruption of macropore systems and lateral movement of I5N occurs by mass flow or diffusion without barriers, for measuring enriched I5N was a loam in the 0- to 10-cm depth and a sandy clay loam in which temperatures may be affected by heat conducted into the soil by the steel cylinder (Olson, 1980). It is necessary to identify how...
interaction existed between harvested row position and N-fertilization rate: No significant difference in total-N uptake resulted in a significant yield increase. There were not significantly different. However, N-fertilization (three inside and the three outside of the microplots) and N-fertilization rate for total-N uptake. These results show that plant responses were the same on the six rows (Fig. 1) were the criterion used to determine the area required for lateral root development of the product by the authors or the USDA. Trade and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment.

Above ground yields and total-N uptake across the three microplots or between Rows 1 through 6 (Table 2) were the same on the microplots and unlabeled fertilizer N was assumed to have the same atom number as that measured for Ar. Measured values of Ar were 0.3861 and 0.3822 atom %15N as that measured for Ar.

**Table 3.** Effect of row position, relative to the microplot border, on harvest plant material (Table 3) showed the same results, differences in Ef between Rows 3 and 4, the microplot border decreased most rapidly at the microplot border between Rows 3 and 4. The fraction of total N uptake derived from 15N enriched fertilizer was calculated using Eq. [2].

**Atom %15N in plant material from uptake plot Row**

<table>
<thead>
<tr>
<th>Row Position</th>
<th>1st outside</th>
<th>1st inside</th>
<th>2nd outside</th>
<th>2nd inside</th>
<th>3rd outside</th>
<th>3rd inside</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3861</td>
<td>0.3822</td>
<td>0.3861</td>
<td>0.3822</td>
<td>0.3861</td>
<td>0.3822</td>
</tr>
<tr>
<td>2</td>
<td>0.3861</td>
<td>0.3822</td>
<td>0.3861</td>
<td>0.3822</td>
<td>0.3861</td>
<td>0.3822</td>
</tr>
</tbody>
</table>

**Means with the same letter are not significantly different at the level of probability.**

**Fertilizer Nitrogen-1**

| Fertilizer Nitrogen-1 (kg N ha-1) | Mean | 15b | 24a | 102 | 107 | 104a | 8198 | 8605 | 8401a | 102 | 107 | 104a |
|----------------------------------|------|-----|-----|-----|-----|-----|------|------|------|------|-----|-----|-----|
| No Fertilizer                    | 0    | 0   | 0   | 0   | 0   | 0   | 0    | 0    | 0    | 0    | 0   | 0   | 0   |
| 15N-enriched Fertilizer          | 1    | 2   | 1   | 2   | 1   | 2   | 1    | 2    | 1    | 2    | 1   | 2   | 1   |

**Rate of N-fertilization did not result in a significant yield increase.**
increased application rate of 5N-enriched fertilizer in...

Fig. 2. Effect of row position, relative to the microplot border, upon...

Symmetry about microplot borders...

Comparison of Row 6 data for the 56 and 112 kg

CONCLUSIONS

Microplots should be large enough that...

Normal cultural practices were possible. Use of plow- or disk-tillage or...
helps minimize costs associated with the use of 15N fertilizer while eliminating costs of installing barriers around 15N-fertilized microplots.

ACKNOWLEDGMENTS

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