Nitrogen Source and Placement Effects on Nitrous Oxide Emissions from Irrigated Strip-Till and No-Till Corn Production Systems.[1]

Ardell D. Halvorson and Stephen J. Del Grosso
USDA, Agricultural Research Service
2150 Centre Avenue, Building D, Suite 100, Fort Collins, CO 80526-8119
Email: Ardell.Halvorson@ars.usda.gov Phone: 970-492-7230

ABSTRACT

Nitrogen (N) source and placement effects on soil nitrous oxide (N_2O) emissions from strip-till (ST) and no-till (NT), irrigated continuous corn fields were evaluated in 2011 near Fort Collins, CO on a clay loam soil. Emissions were monitored from plots receiving granular urea, ESN®[1], SuperU®, and liquid UAN (ST only) at a rate of 202 kg N/ha. The N sources were surface band applied near the corn row or broadcast applied, then watered (19 mm irrigation water) into the soil the day after application. Nitrous oxide fluxes were measured during the growing season using static, vented chambers for gas sample collection, about three times per week, and analyzed with a gas chromatograph. Cumulative increases in daily N_2O fluxes were more rapid for urea and UAN than for ESN or SuperU following N fertilizer application. SuperU, ESN, and UAN had significantly lower growing season N_2O emissions than granular urea in ST and NT, irrigated corn production systems in 2011. Corn grain yields did not differ among N sources under NT, but SuperU produced higher yields than ESN and UAN under ST, and yields equal to urea. Growing season N_2O emissions were lower with surface broadcast placement than with surface band N applications for all N sources under both tillage conditions. The study shows that N source selection and placement are important management decisions for reducing N_2O emissions from Central Great Plains' cropping systems.

INTRODUCTION

The greenhouse gas, N_2O, is produced in soils through nitrification and denitrification processes with agriculture contributing approximately 67% of total U.S. N_2O emissions (USEPA, 2010). Although small in concentration, the global warming potential (GWP) of N_2O is approximately 298 times greater than that of CO_2 (Solomon et al., 2007), therefore, it is important to develop management practices to reduce N_2O emissions from agricultural systems. Nitrogen fertilizer application, tillage, cropping system, and N source can impact N_2O emissions from irrigated Central Great Plains cropping systems (Mosier et al., 2006; Halvorson et al., 2008, 2010a,b, 2011).

Research comparing the effects of N placement on N_2O emissions in crop production systems is limited (Engel et al., 2010; Hultgreen and Leduc, 2003; Liu et al., 2006). Engel et al. (2010) reported less N_2O emissions with broadcast N than when the N was banded. This paper reports on effects of N fertilizer source and placement (surface broadcast and band) on growing season N_2O emissions under ST and NT, irrigated continuous corn production in 2011.

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MATERIALS and METHODS

The N_2O data was collected from irrigated, continuous corn N plots under ST and NT production located on a Fort Collins clay loam soil at the Agricultural Research, Development, and Education Center (ARDEC) north of Fort Collins, CO. The ST treatment had continuous corn production since 1999 and the NT treatment since 2006. Both tillage treatments in these N source studies received 202 kg N/ha the previous 2 years. Fertilizer N sources evaluated were granular urea (46% N), a polymer-coated granular urea (ESN, 44% N), a stabilized granular urea (SuperU, 46% N), and liquid urea-ammonium nitrate (UAN, 32% N) in ST only. The N sources were either surface band (bd) applied next to the row or broadcast (bc) applied at corn emergence and watered into the soil with about 19 mm of water applied with a linear-move sprinkler irrigation system the day after application. The polymer-coated urea, ESN, is produced by Agrium Advanced Technologies, Inc., Loveland, CO. SuperU was a finished urea product produced by Agrotain International, St. Louis, MO (now KOCH Agronomic Services, LLC) with a homogenous blend with urease (NBPT) and nitrification (DCD) inhibitors included at the time of production.

The N treatments were arranged in a randomized complete block design with three replications. Each N source plot was 3(ST) or 2.7(NT) m long x 4.6 m wide. The ST operations were strip-till in fall, plant in late April, spray (after crop emergence) for weed control (twice), and harvest. The NT field operations were the same as ST without the strip-tillage operation. Grain yield was measured from 24 corn plants at maturity in each plot, removing the ear, and shelling it to determine grain weight at 15.5% water content. Yields were calculated using counts of established plant populations.

Greenhouse gas fluxes were generally monitored three days per week during the growing season in each N treatment. Gas samples were collected from two sampling sites within each N treatment replicate for a total of six gas samples for each treatment on each sampling day. A vented chamber technique was used to collect the gases in the field and a gas chromatograph used to analyze for gas concentration as described by Mosier et al. (2006). A randomized complete block ANOVA was used to determine differences in N_2O emissions and grain yield among N source treatments.

RESULTS AND DISCUSSION

Cumulative growing season N_2O emissions for each N source and placement treatment during 2011 are shown in Fig. 1 for ST. The N was applied on May 25^{th} (DOY 145) followed by an immediate (within a few days after application) rise in N_2O emissions from urea (Ubd and Ubc) and UAN (UANbd and UANbc). SuperU (SUbd and SUbc) and ESN (ESNbd and ESNbc) had lower N_2O emissions immediately following N application than urea or UAN under both ST and NT production (data not shown). The growing season N_2O emissions were consistently less with the broadcast applications than with the band applications. Differences between N sources and placements are shown in Fig. 2 for ST and Fig. 3 for NT. Dry granular urea had the highest level of growing season N_2O emissions and was significantly greater than all other N sources (Fig. 2 and Fig. 3). Consistent with previous work at this location (Halvorson et al., 2010b, 2011), liquid UAN resulted in lower soil N_2O emissions that granular urea under ST corn production. Broadcast application of the N fertilizer resulted in lower N_2O emissions than surface banding across all N sources and both tillage systems.

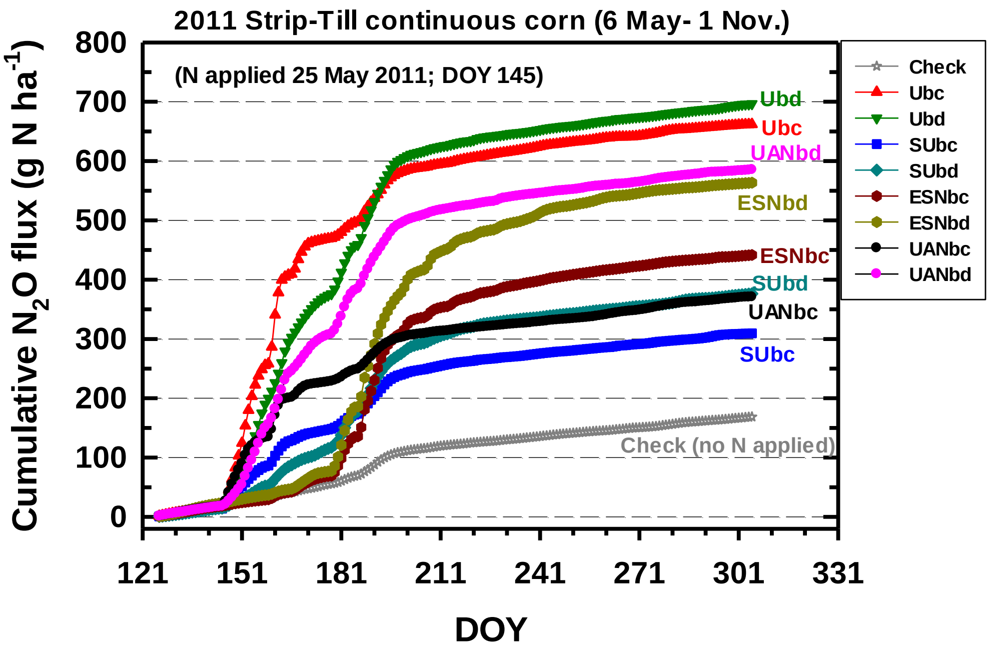

Fig. 1. Cumulative daily N_2O flux during the 2011 ST growing season for each N source and placement treatment.

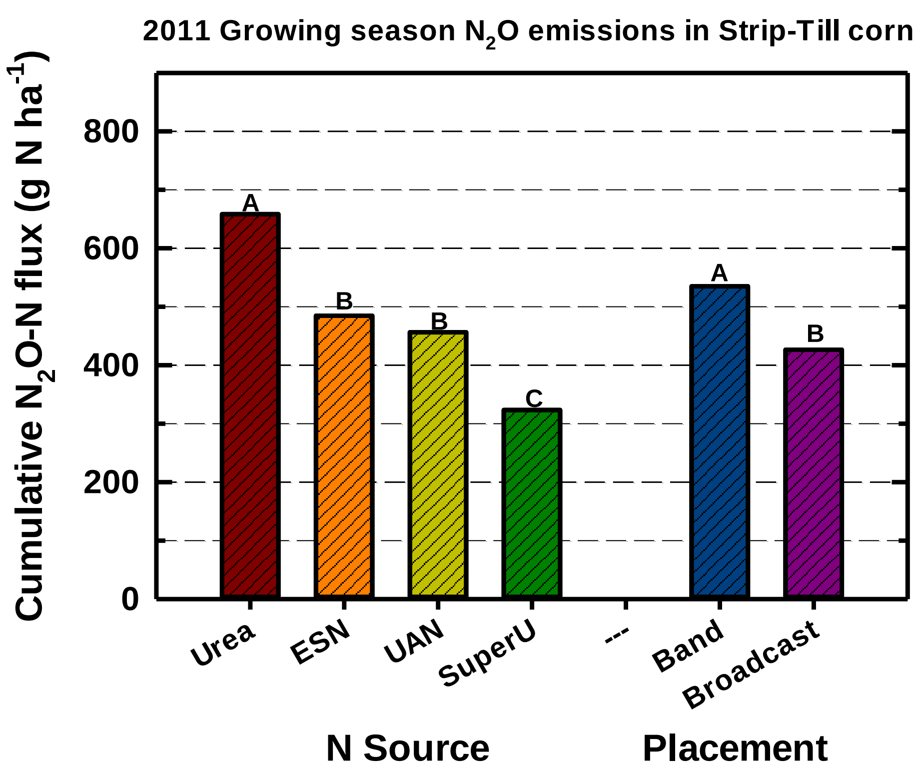

Fig. 2. Growing season cumulative N_2O flux for each N source and N placement in ST system. Bars with the same letter on top are not significantly different at $P = 0.05$.

Averaged across tillage systems, growing season N_2O emissions (Fig. 4) for the granular N sources showed the same patterns of emissions as shown in Figs. 2 and 3. Urea had the highest level of emissions, with ESN having lower emissions than urea but higher than SuperU. Averaged across tillage systems, N fertilizer placement effects stayed the same, banding N on the soil surface at crop emergence resulted in greater N_2O emissions than broadcasting (Fig. 4). The reason for banding having greater N_2O emissions than broadcasting is not clear, but these results are in agreement with those of Engel et al. (2010). Engel et al. (2010) suggested that placing urea in a concentrated band results in the accumulation of high levels of nitrite which reduces the rate of urea hydrolysis and nitrification, increasing N_2O emissions. Venterea et al. (2007) showed a linear increase in N_2O emissions with increasing soil nitrite levels. Possibly the broadcast application resulted in a lower concentration of nitrite per unit of soil area, allowing for faster hydrolysis of urea and nitrification of NH_4 to NO_3, resulting in less N_2O production. Comparing tillage systems in 2011, N_2O emissions were greater with NT than with ST when averaged over the same N sources and placement treatments (Fig. 4). Corn grain yields did not differ among N sources under NT, but SuperU produced higher yields than ESN and UAN under ST, and yields equal to urea. When averaged over tillage systems, grain yields did not vary among N sources (data not shown) or with N placement.

The surprising result of N_2O emissions being higher with banding than broadcast N application, suggests that N placement effects on N_2O emissions needs to be evaluated further under other soil, cropping system, and climatic conditions to obtain a broader perspective on the effects of N placement on N_2O emissions from agricultural systems.

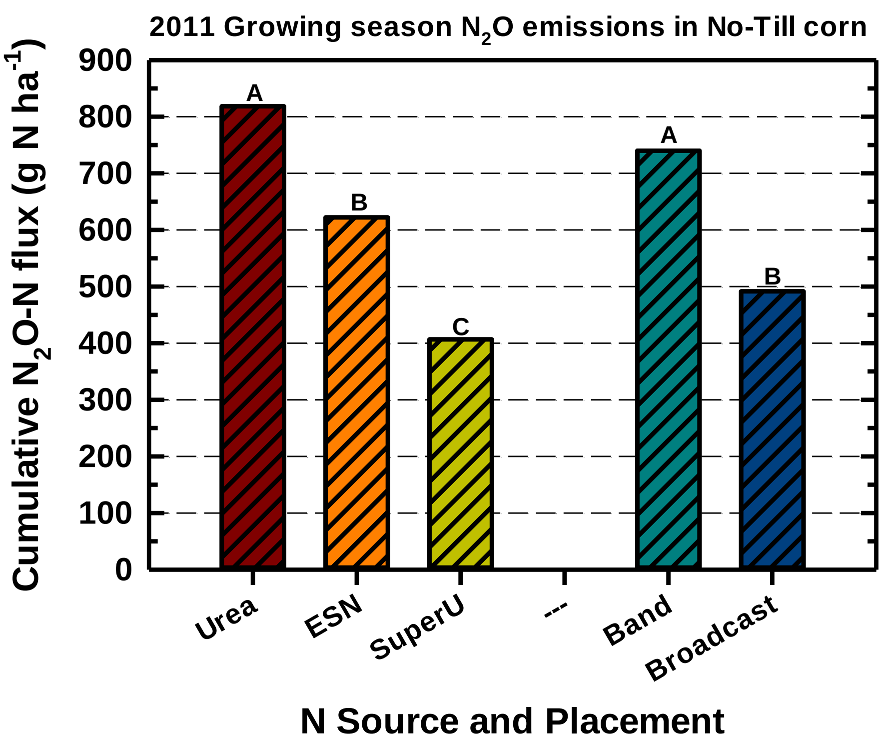

Fig. 3. Growing season cumulative N_2O flux for each N source and N placement in NT system. Bars with the same letter on top are not significantly different at $P = 0.05$.

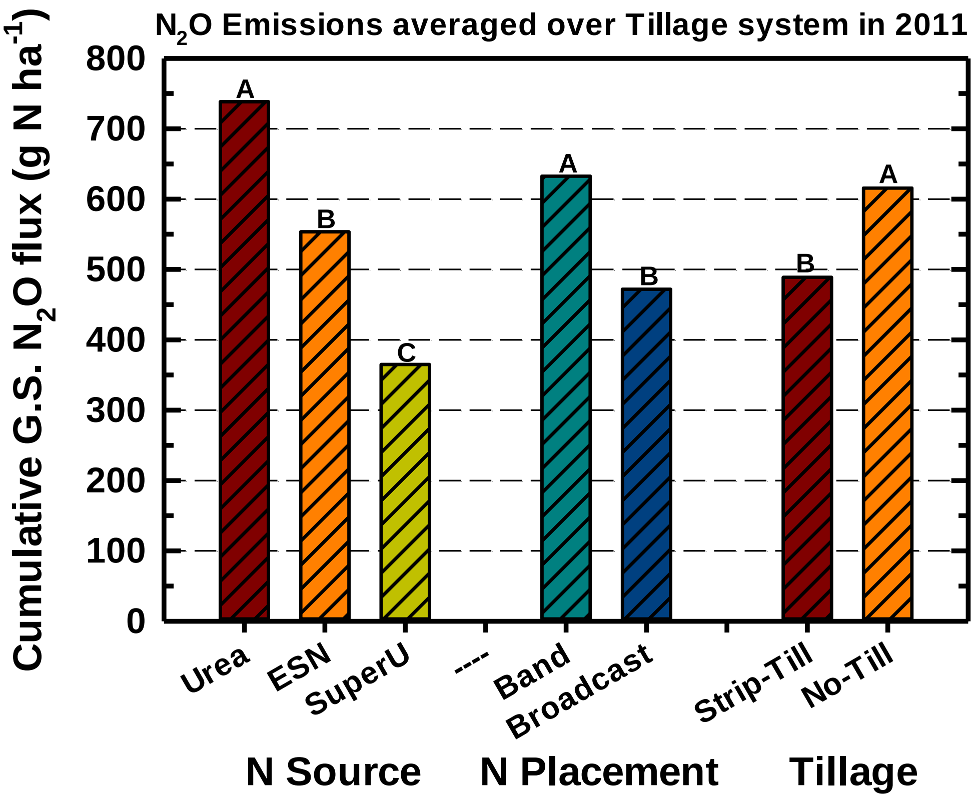

Fig. 4. Cumulative growing season N_2O flux averaged over tillage as affected by N source and placement with N applied at crop emergence. Bars with the same letter are not different at $P = 0.05$.

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