Nitrous Oxide Response to Nitrogen Fertilizer in Irrigated Spring Wheat in the Yaqui Valley, Mexico

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OBJECTIVE & OVERVIEW

To investigate trade–offs between fertilizer N input, wheat yield, and nitrous oxide (N_2O) emissions, to inform management strategies that can mitigate N_2O emissions without compromising productivity and economic return.

- The Yaqui Valley, one of Mexico's major breadbaskets, encompasses ~225,000 ha of cultivated, irrigated cropland, up to 75% of which is planted to spring wheat annually (Fig. 1).
- Region is agro-ecologically representative of environments where 40% of wheat is produced in the developing world.

Fig. 1. Yaqui valley a) crop landscape, b) location, and c) CIMMYT offices in Obregon.

- Nitrogen (N) fertilizer applications to spring wheat have nearly doubled since the 1980s, and currently average around 300 kg N ha^{-1}.
- High N rates are a substantial component of total crop production costs, and also may result in significant N losses to the environment via gaseous emissions.
- Nitrous oxide (N_2O), a potent greenhouse gas (GHG) is produced naturally by microbial denitrification and nitrification.
- N_2O emissions increase following soil management activities, especially fertilizer N application, and particularly when this input exceeds crop requirement.

EXPERIMENTAL SITE &DESIGN

- Yaqui Valley, near Ciudad Obregon, Sonora, Mexico (27°N:109°W; 40 masl; Fig. 1).
- Sandy clay mixed montmorillonite (Typic Caliciorthid).
- RCBD; 8 N rate treatments (0, 40, 80, 120, 160, 200, 240 and 280 kg N ha^{-1}); 6 reps.).
- GHG/soil N measurements (0, 80, 160, 240 and 280 kg N ha^{-1}; 4 reps; Fig. 2).

502	503	402	403	108	101
507	506	407	406	107	102
504	508	405	401	106	103
505	501	408	404	105	104
607	608	302	303	202	205
603	606	305	301	206	208
605	601	304	307	207	201
602	604	308	306	203	204

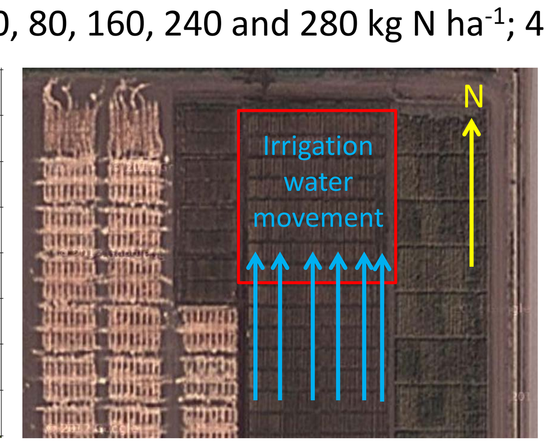


Fig. 2. Experimental RCBD (Block 810, CENEB, Yaqui Valley, Ciudad Obregon, Sonora, Mexico). GHG and soil N measurements taken from shaded plots (each 3.2m x 5m).

MANAGEMENT & METHODS

- Spring wheat (*Triticum turgidum* var. durum) after summer rotation with unfertilized maize.
- Fertilizer (pelletized urea) applied to furrows (fondo) prior to irrigation (Fig. 3).
- Manual gas flux chamber technology to measure N_2O (Fig. 4).

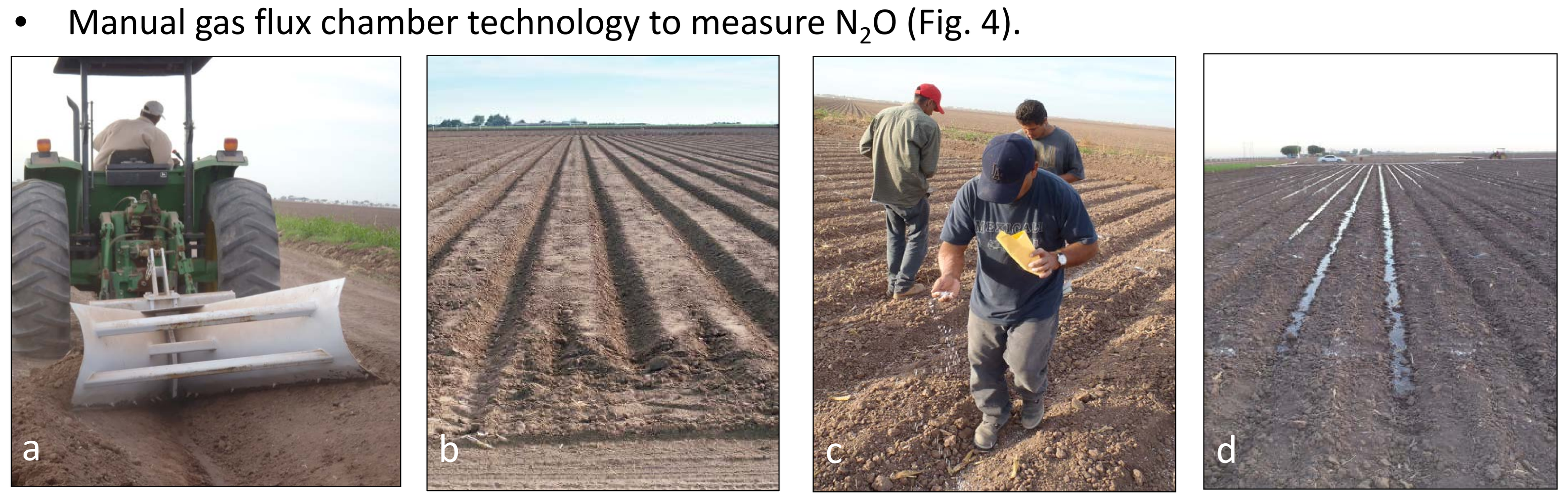


Fig. 3. Management practices at site: a) creating drainage during b) bed (lomo) and furrow (fondo) preparation, prior to c) furrow fertilization with pelletized urea and d) irrigation.

MANAGEMENT & METHODS continued

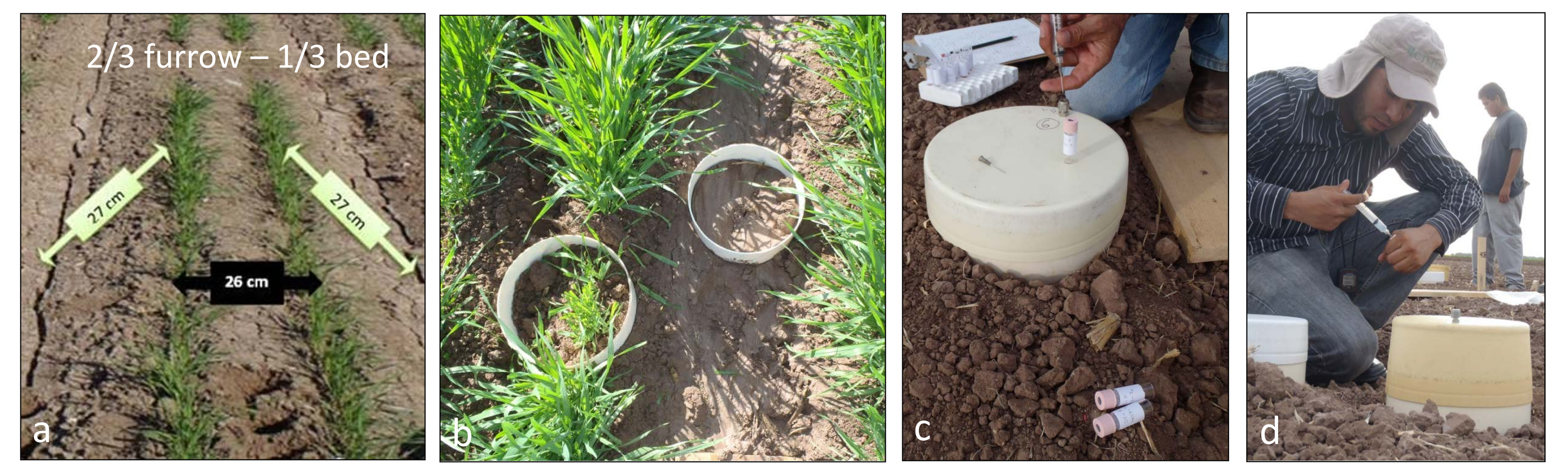
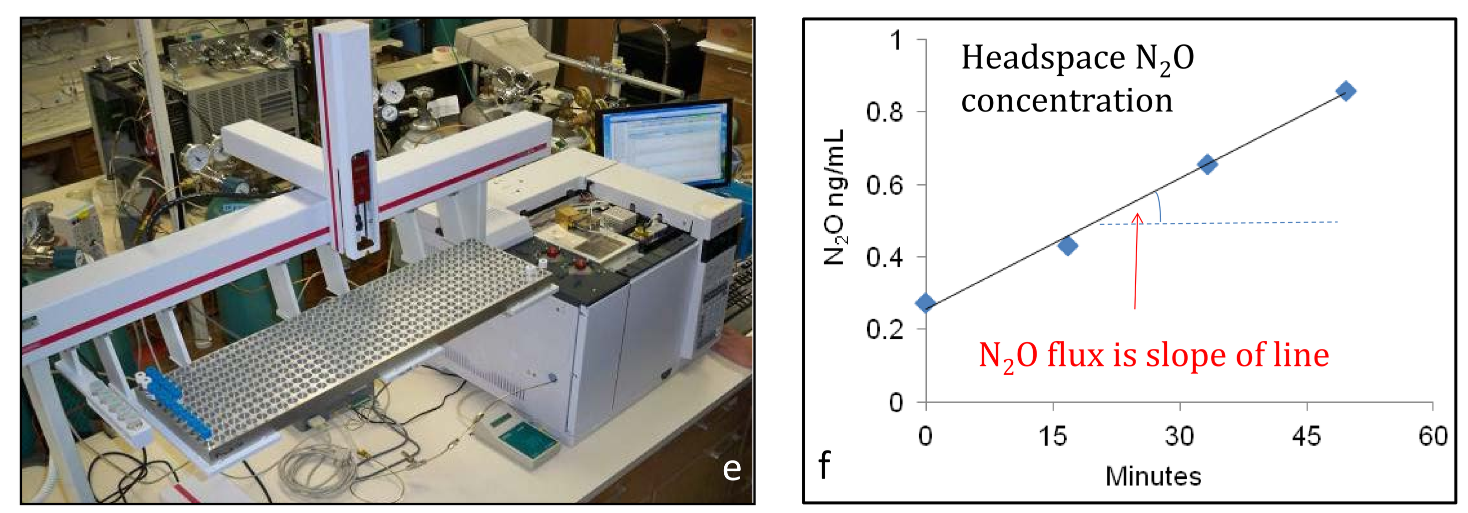


Fig. 4. Manual chamber sampling and analysis for N_2O: a) Bed and furrow dimensions, b) chamber placement within each plot, c) gas sample extraction from chamber head-space, d) sample vial filling, e) automated gas chromatography analysis, and f) N_2O concentration vs. sampling time (δC/δT) graph for N_2O flux calculations.



RESULTS

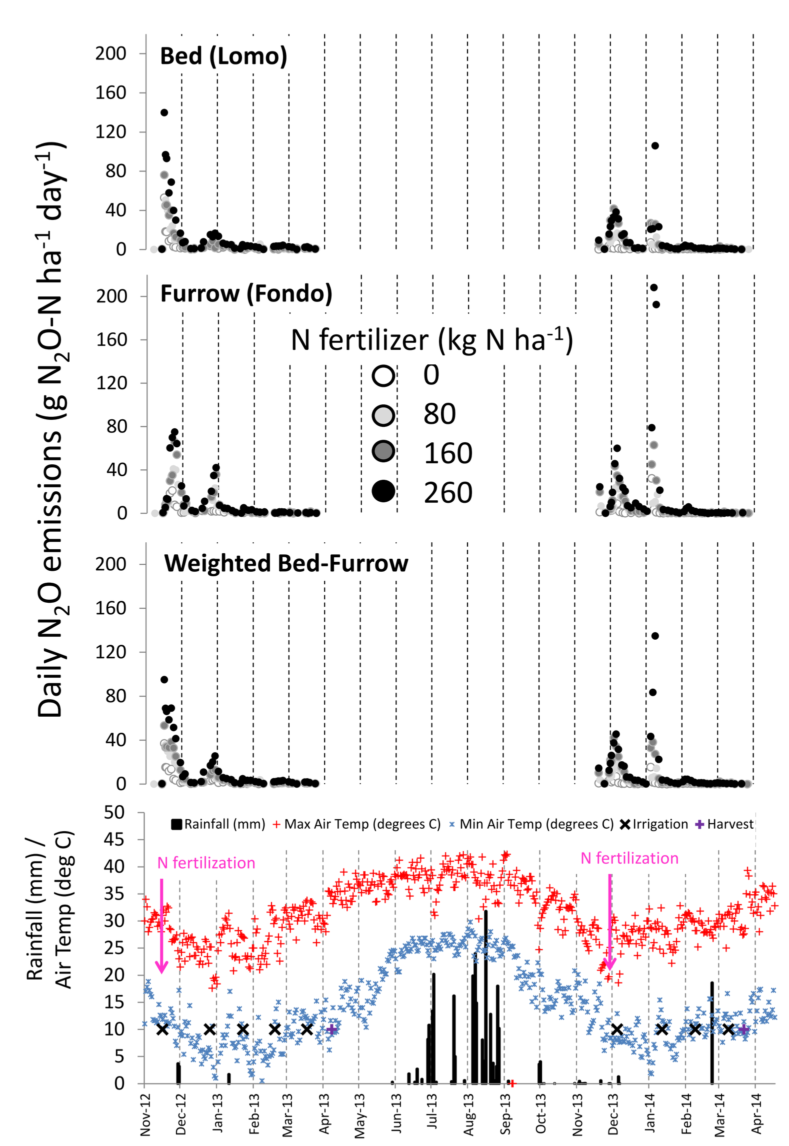


Fig. 5. Daily N_2O emissions during 2012-2013 and 2013-2014 wheat seasons.

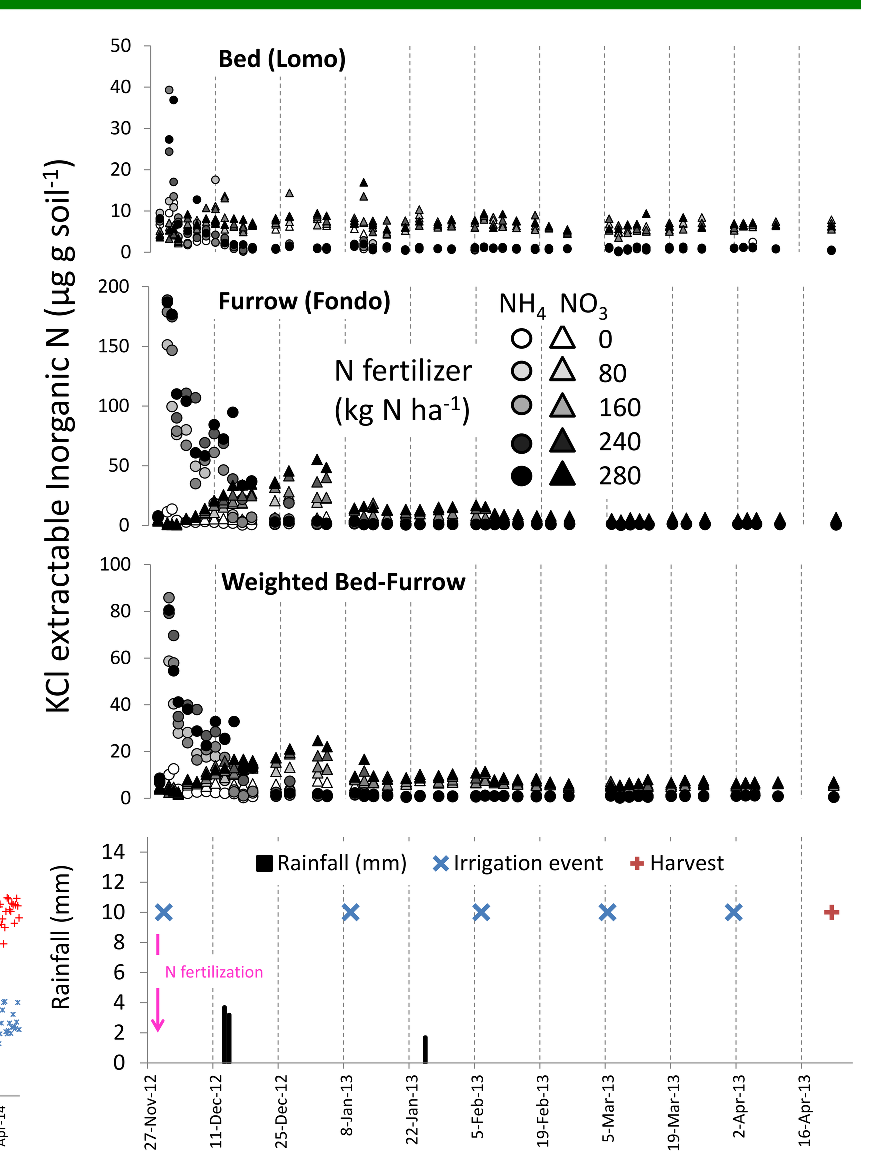


Fig. 6. Inorganic N concentrations during 2012-2013 wheat season.

RESULTS continued

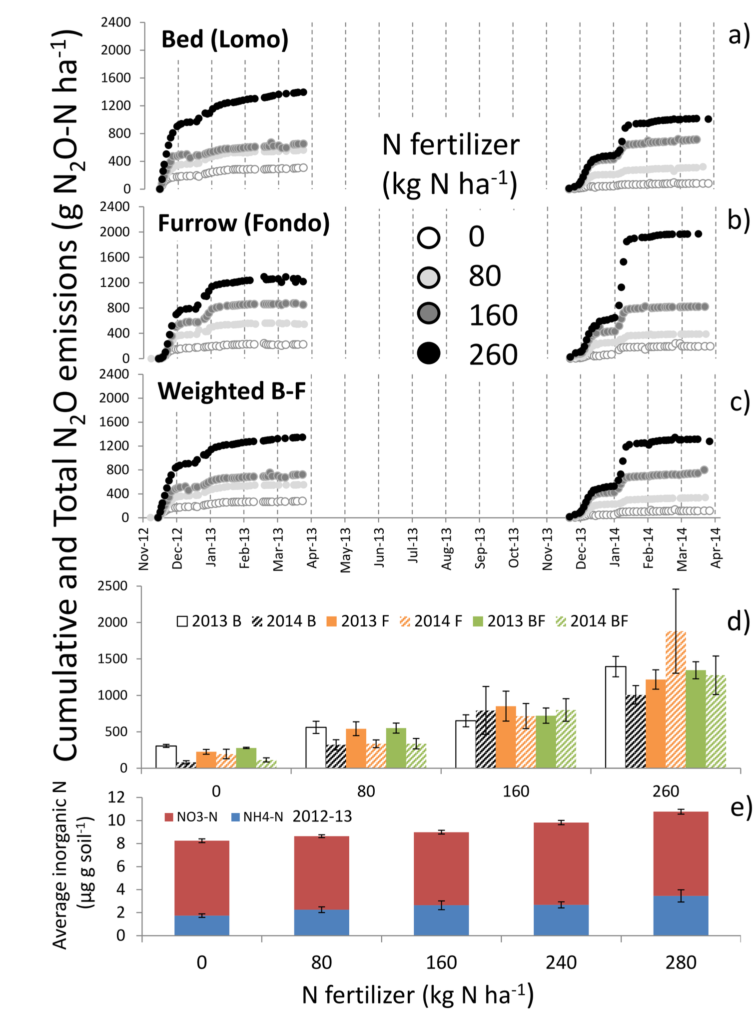


Fig. 7. a-c) Cumulative and d) total N_2O emissions and e) average inorganic N concentrations.

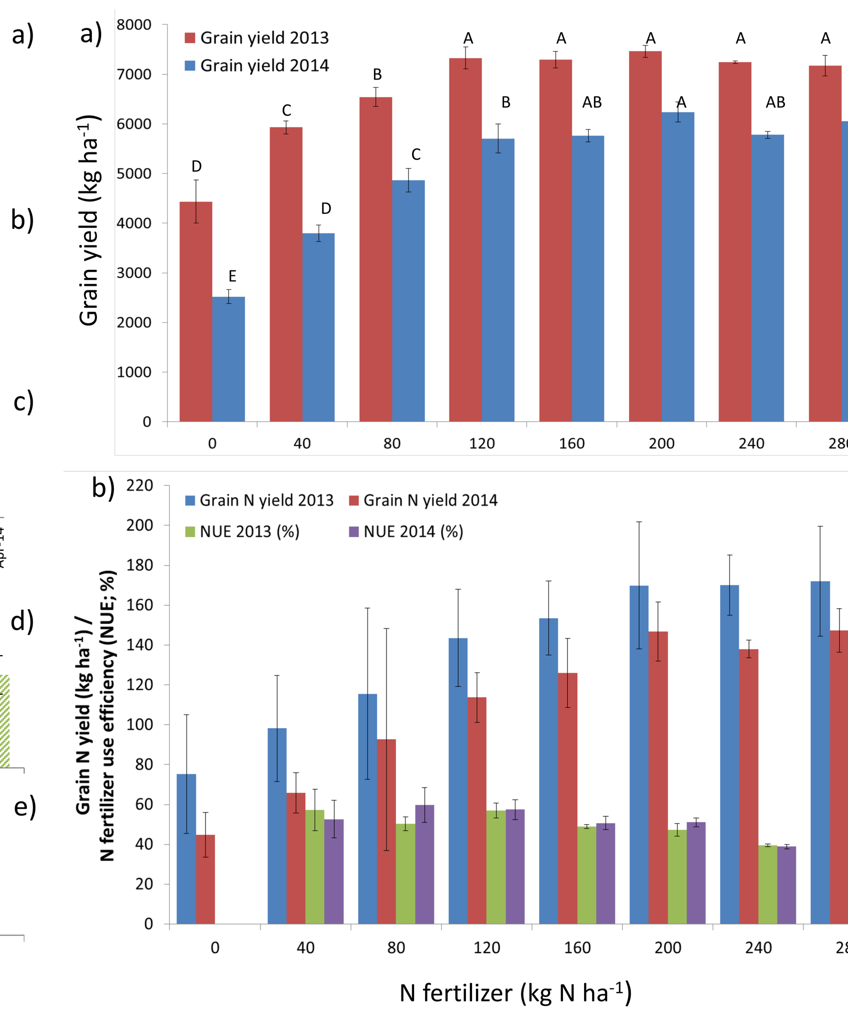


Fig. 8. a) Grain yield and b) grain N yield and nitrogen use efficiency in 2013 and 2014.

- Daily N_2O emissions (Fig. 5) and soil inorganic N concentrations (Fig. 6) increased following N fertilizer application.
- Total N_2O emissions (Fig. 7 a-d) and average soil inorganic N concentrations (Fig. 7 e) increased with increasing N fertilizer rate in a non-linear manner.
- Grain yield did not increase with increasing N rate above 120 kg N ha^{-1} in 2013 and 200 kg N ha^{-1} in 2014 (Fig. 8a).
- Grain N yield increased with increasing N rate up to 200 kg N ha^{-1} in 2013 and 2014 (Fig. 8b).
- Fertilizer N use efficiency decreased with increasing N rate above 120 kg N ha^{-1} (Fig. 8b).
- N_2O emissions increased substantially after spring wheat yield and biomass reach annual thresholds (Fig. 9).

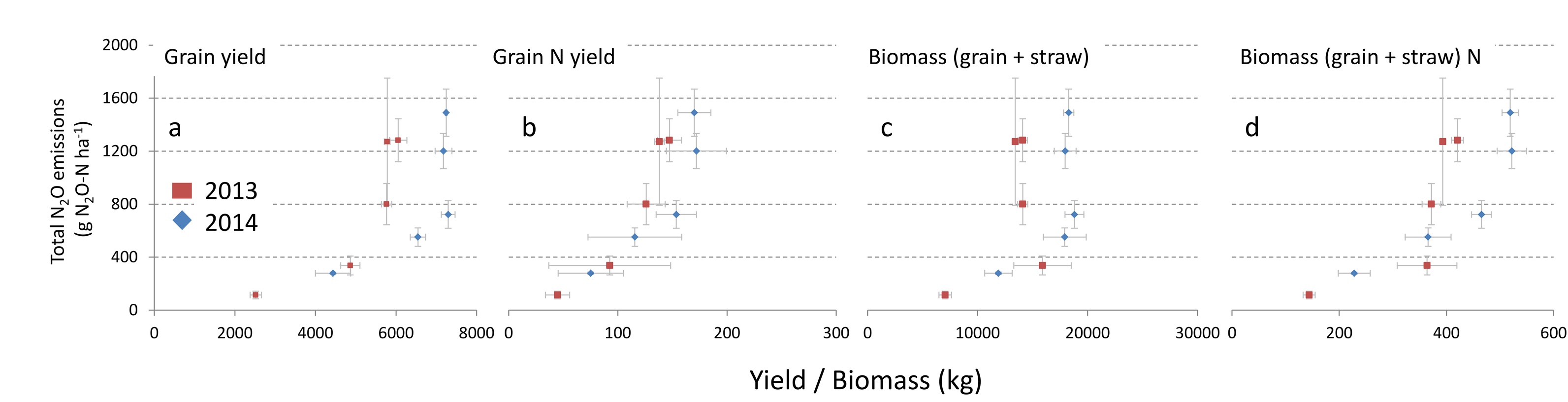


Fig. 9. Total N_2O emissions vs. a) grain yield, b) grain N yield, c) biomass, and d) biomass N

In 2013, a reduction in N fertilizer rate from 280 to 120 kg N ha^{-1} would have resulted in N_2O mitigation of 1.5 kg ha^{-1}. If we assume all spring wheat planted that year in the Yaqui Valley (~160,000 ha) received these N fertilizer rate reductions, equivalent reductions of CO_2 would have totaled over 700 Gg.

CONCLUSIONS and FUTURE WORK

- Large reductions in N_2O emissions at the field and regional scale can be achieved without reducing spring wheat yield.
- We will explore opportunities for Yaqui Valley farmers to take advantage of global C markets, to generate income from any improved N management practices they adopt.

CGIAR Research Program on Climate Change, Agriculture and Food Security CCAFS MICHIGAN STATE UNIVERSITY W.K. Kellogg Biological Station KBS LTER

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