Atmósfera (2003) 231-244

Nitrous oxide flux in maize and wheat cropped soils in the central region of Mexico during "El Niño" year 1998

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Received May 24, 2002; accepted September 11, 2003

RESUMEN

En 1998 se midieron las emisiones de óxido nitroso (N_2O) de suelos agrícolas utilizados para cultivar trigo y maíz en los estados de Hidalgo y Tlaxcala, en México. Para un campo irrigado de trigo (El Teñhé, Hidalgo), se obtuvo un flujo promedio de -10.85 $\mu g\ N_2O\text{-}N\ m^{-2}\ h^{-1}$ para el ciclo total (155 días entre diciembre y mayo). En este caso se observaron valores negativos elevados en el espacio poroso relleno de agua (WFPS, por sus siglas en inglés), cercanos a 70%. El flujo promedio para el ciclo completo (269 días entre marzo y diciembre) en un campo irrigado de maíz fue de 37.43 $\mu g\ N_2O\text{-}N\ m^{-2}\ h^{-1}$. En éste, se encontraron más flujos negativos significativos, con WFPS cercanos a 45% o menos. Estos resultados pueden estar influenciados por el fuerte "El Niño" que ocurrió a mediados de 1998. En el estado de Hidalgo 21% de las mediciones mostraron que el suelo actuó como un sumidero para el óxido nitroso. Las muestras del estado de Tlaxcala señalan que esos suelos actuaron como emisores. En los campos de temporal del estado de Tlaxcala se obtuvo un flujo promedio de 121 $\mu g\ N_2O\text{-}N\ m^{-2}\ h^{-1}$ para el campo de trigo. La temporada de cultivo duró 142 días, de julio a diciembre. Para el campo de maíz el flujo promedio fue de 285.61 $\mu g\ N_2O\text{-}N\ m^{-2}\ h^{-1}$ y la temporada duró 246 días, de abril a diciembre.

ABSTRACT

Emissions of nitrous oxide (N_2O) were measured in agricultural lands used for farming wheat and maize during 1998 in the states of Hidalgo and Tlaxcala in Mexico. In an irrigated wheat field (El Teñhé, Hidalgo), an average flux of -10.85 $\mu g\ N_2O\text{-}N\ m^{-2} h^{-1}$ was obtained for the total cycle (155 days between December and May). There, high negative values were observed with Water Fill Porous Space (WFPS) close to 70%. The average flux of the complete cycle (269 days between March and December) in an irrigated maize field (El Progreso, Hidalgo) was 37.43 µg N_2O-N $m^{-2}h^{-1}$. In this case, more significant negative fluxes were found with WFPS close to 45% or less. These last results may have been influenced by the strong "El Niño", which occurred in the middle of 1998. Twenty one percent of the measurements in the state of Hidalgo showed soil acting as a nitrous oxide sink. The samples from Tlaxcala showed that these fields acted as emitters. In the rain fed fields in the state of Tlaxcala, an average flux of 121 µg N_2O-N$m^{-2}h^{-1}$ was obtained for the wheat field. The farming season lasted 142 days, from July to December. In addition, for the maize field the averaged flux was 285.61 µg N_2O-N $m^{-2}h^{-1}$. The farming season lasted 246 days, from April to December.

Key words: Nitrous oxide, soils, emissions, Mexico, greenhouse gases, El Niño, ENSO

1. Introduction

The nitrous oxide has a double effect on the atmosphere: it is a greenhouse gas, and it is a precursor of nitric oxide (NO) in the stratosphere, which in turn acts like an ozone scavenger. Obtaining reliable global inventories of N_2O emissions has been difficult because only a limited number of measurements in sites with controlled, or well-known conditions, are available. The generalization of such values has lead to great discrepancies between the estimates of several authors. An eightfold difference between the lower estimate of 3 Tg N_2O-N yr^{-1} and the upper estimate of 24 Tg N_2O-N yr^{-1} can be found in the literature (Sanhueza, 1990; Kroeze, 1993; Langeveld, 1993; Metz, 1993; Wiesen, 1993; Matthews, 1994; Schiller, 1996; Teira-Esmatges *et al*., 1998).

While only a fraction of N_2O produced is liberated to the atmosphere during denitrification, the remainder is reduced to molecular nitrogen as the final product. Teira-Esmatges *et al.*, (1998) find that denitrification is favored by high soil water content, with values of Water Filled Pore Space (WFPS) between 45 and 70% or near its field capacity. Veldkamp *et al*. (1998) find that the process of denitrification prevails for WFPS values higher than 60%. At values higher than 80%, N_2O is consumed and the most important product is molecular nitrogen. In addition, 30-60% of N-emissions were NO as the main product from nitrification.

Table 1 shows nitrous oxide fluxes obtained in several tropical sites and in different ecosystems like agricultural lands, grasslands and forests, as well as under different conditions such as: drought, after ploughing, fertilization, irrigation or raining. The reported fluxes vary from negative values (indicating that the soil acts as a sink (Sanhueza *et al*., 1990)), to values higher than 1000 µg N_2O-N m^{-2} h^{-1} in humid and fertilized fields (García-Méndez *et al*., 1992).

Extensive and reliable measurements of N_2O emissions under many different conditions of soils, as well as crop management, are needed to build up a global database of emission fluxes. These are essential for testing and developing emission models. This information will also help to improve inventories and to develop mitigation strategies aiming to reduce the release of fertilizers to the atmosphere.

In this work, N_2O sampling was carried out under actual farming conditions during the extreme conditions of "El Niño" of 1998 in central Mexico. Samples were taken from irrigated and rain fed

Table 1. Nitrous oxide fluxes in natural systems and tropical zones.

E.F. $\mu g\ N_2O\text{-}N\ m^{-2}\ h^{-1}$	Site	Conditions	Reference
4.18	Venezuela (savanna)	grazing land, dry season	Hao *et al.*, 1988
16.72	Venezuela (savanna)	irrigated grazing land	Hao *et al.*, 1988
9.1	Jalisco, México	forest, raining season	Vitousek *et al.*, 1989
0	Jalisco, México	forest, dry season	Vitousek *et al.*, 1989
26.4	Jalisco, México	cultivation of maize	Vitousek *et al.*, 1989
9.5 to 41.7	Venezuela	forest	Sanhueza *et al.*, 1990
- 6.0 to 23.4	Venezuela (savanna)	dry season and raining season	Sanhueza *et al.*, 1990
5 to 25	Jalisco, México	raining season	García *et al.*, 1991
<3.0	Jalisco, México	dry season	García *et al.*, 1991
29	Jalisco, México	raining season	García *et al.*, 1992
99.5	Jalisco, México	grazing land, fertilized	García *et al.*, 1992
0	South Africa	intense drought	Levine *et al.*, 1996
27	Costa Rica	grazing land, humid tropical zone	Veldkamp *et al.*, 1998
49	Costa Rica	grazing land-herb, humid tropical zone	Veldkamp *et al.*, 1998
258	Costa Rica	fertilized grazing land, humid tropical zone	Veldkamp *et al.*, 1998
27.3	Costa Rica	banana plantation without fertilizer	Veldkamp *et al.*, 1997
240 to 560	Costa Rica	banana plantation, fertilized	Veldkamp *et al.*, 1997
480 to 1400	Costa Rica	under the banana foliage	Veldkamp *et al.*, 1997
318 to 4160	Sonora, México	wheat, fertilized before sowing	Ortiz Monasterio, 1994
128 to 318	Sonora, México	wheat, fertilized during sowing	Ortiz Monasterio, 1994
-10.85	Hidalgo, México	wheat, fertilized and irrigated	this work
37.43	Hidalgo, México	maize, fertilized, intense drought	this work
121	Tlaxcala, México	wheat, fertilized, raining season	this work
285.61	Tlaxcala, México	maize, fertilized, raining season	this work

fields of the states of Hidalgo and Tlaxcala. In these parts of Mexico, “El Niño” brings a delay of the rainy season, and when it starts, rains are stronger and more sustained (Conde *et al*., 1999). In 1998 “El Niño” brought an intense drought from March to June and heavy rains later on, leading to a delay of the farming cycle. “El Niño” of 1998 was considered the most intense in the century (Magaña *et al*., 1999).

2. Method and material

a. Selection of sites

The fields were selected with the help of personnel from the Central Region of the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP, for its acronym in Spanish).Two fields cultivated using machinery, fertilizers, pesticides, and irrigation systems, were selected in the Valley of El Mezquital in the state of Hidalgo, at the northern edge of the Basin of Mexico. This valley is located in the southwest region of the state and is formed by 20 municipalities with an arable surface of 45,000 ha, 27,000 of which are irrigated using residual water from Mexico City, rich in nitrogen and phosphorus. The selected fields are located at 20^0 11' 47.6" N and 99^0 10' 30.9" W for the wheat field and 20^0 14' 48.4" N and 99^0 09' 53.1" W for the maize field. Both locations are at 2,030 m above sea level. The selected crops (wheat and maize) account for most of cultivated area in this state. Table 2 shows some soil properties of the fields using integrated sampling. Eight sampling campaigns were carried out in each field, each one with an average duration of three days.

Table 2. Average parameters value of the soil at the sampled fields

Parameter	Teñhé, Hidalgo Wheat	Progreso, Hidalgo Maize	Apizaco, Tlaxcala Maize	Apizaco, Tlaxcala, Wheat
Bulk density, gcm^{-3}	1.02	0.88	1.3	1.4
pH	6.8-7.2	6.9-7.2	5.4-6.4	5.8-7.1
E.C., mmhos cm^{-1}	356	16	13	11
Soil type	loam	loam	sandy	sandy
Organic matter, %	3.6	3.5	1.4	1.2
Mineralized N, (kg N ha^{-1} yr^{-1})	269	——	60	50
N of nitrates, g/kg	0.210	——	0.030	0.025
N of Ammonia, g/kg	0.010	——	0.300	0.300
P , g/kg	0.077	——	0.055	0.050
K , g/kg	0.775	——	0.200	0.170
Field capacity, %	40	41	24	27

Two rain-fed fields were chosen in the municipality of Apizaco in the state of Tlaxcala. One plot was for wheat and another for maize. In this municipality, about 200,000 ha are dedicated to agriculture. Of this area, only 2% is irrigated. The dominant crop is maize (70%), followed by wheat (20%). A shallow and dry watercourse separates the fields. The geographical coordinates of the selected fields are the following: 19^0 23' 28.9" N, 98^0 07' 19.9" W at 2,430 m above sea level.

b. Sampling and analysis

Sampling under controlled experimental conditions is highly desirable yet, difficult to fulfill under actual farming conditions. Sampling was planned so it approached as closely as possible a factorial design 2^3; soil water content, fertilizer and density of plants, were the factors to be managed in two levels. The first, in the state of Hidalgo, corresponded to intensive farming with the use of irrigation, machinery and fertilization. The second, in the state of Tlaxcala, corresponding to an extensive and more traditional way, with little use of machinery and rain fed. Soil water content was registered before and after irrigation or rain. The effect of the plant density and fertilization was observed by also sampling on the edge of the field (Dobbie and Smith, 2003). However, the lower part of the sampling chambers is vulnerable to vandalism until the plants grow enough to conceal it. Due to vandalism, we lost two of the sampling sites on the edges, and one within one of the fields. After noticing that risk, a plastic chamber was taken to the field and used to complement the measurements, or to replace one of the other chambers in case it was lost to vandalism. In addition, the two fields in the state of Hidalgo were irrigated by intermittent flooding, leading to transport fertilizer from one site to another. For these reasons, the approach to the factorial design was far less than expected. In addition, the rationing of water for irrigation due to the intense drought in early 1998 caused by the strong “El Niño”, lead to changes in the usual fertilization and irrigation programs. In the state of Tlaxcala, the delay of the rainy season forced farmers to postpone sowing in these fields. Later on, drought was followed by a long period of intense and frequent precipitation. This precluded some of the sampling trips to these fields due to flooding of roads, when the trips were done the soil was at its field capacity.

A stainless steel chamber composed of two parts was used for sampling. The lower part, 10 cm high and 26 cm in diameter, was placed in the soil with the bottom at a depth of 2 cm during the full farming season. Chambers were placed on the crop row (sites M-1 and M-2) and between rows (site M-3) without allowing plants to grow within the chamber. During sampling, the upper part was fixed on top of the former by three bolts, with a teflon ring placed between them. The upper part has one sampling port fitted with a gas chromatographic (GC) septum. One upper chamber fits several lower bases. The total volume of the chamber is of approximately 10 liters. The first sample (zero time) was taken after placing and fixing the upper part. Subsequent samples were taken at different time intervals from 10 to 60 minutes using a 10 ml syringe (Hamilton 1010 SL) with blocking valve. The gas samples were transferred to properly sealed vials to be taken to the laboratory for analysis. The soil and ambient temperatures were recorded during sampling. In addition, a sample of adjacent soil was collected from a depth of approximately 5 cm for determining soil water content, organic matter, nitrogen content and pH.

GC/ECD analysis for N_2O was made with a stainless steel column 5 m × 1/ 4", with Porapak Q 80/100 packed column, using the customary gas mixture of 5% methane in argon. A six-port CG valve was used to cut off the injection front to protect the electron capture detector from oxygen in the air. Calibration curves were made by bulb (two liters) to bulb dilution of high purity N_2O in nitrogen.

These sampling and analysis procedures are common, and are used by other workers measuring N_2O emissions from natural systems. There are only small differences in the techniques employed relating to the type and size of the sampling chambers, to the length of the GC-columns, and to the analysis conditions (Seiler *et al*., 1981; Conrad *et al*., 1983; Vitousek *et al*., 1989; Cleemput *et al*., 1993; Schiller *et al.*, 1996; Levine *et al*., 1996; Veldkamp *et al*., 1997; MacKenzie *et al*., 1998; Teira-Esmatges *et al*., 1998).

The precision of analysis expressed as the coefficient of variation (CV) for 10 replicate injections of standards was 3.0%, and the system presented a minimum detection limit of 81.65 ppb. We extensively tested this very well established sampling set-up and analysis procedure in a location nearby the laboratory and found high repeatability, with a coefficient of variation (CV) for six samples of 4.8%.

Equation 1 was used for the determination of the N_2O flows (f),

$$f = \frac{(\Delta C \times 10^{-9} \times V_c \times \rho)}{(\Delta t \times A_c)} \tag{1}$$

where ΔC is the change on concentration in ppbv within a time interval Δt in seconds. V_c is the total volume of the chamber in cm^3, ρ is the density of the air within the chamber in molecules/cm^3 at the atmospheric pressure and ambient temperature of the site, and; A_c is the area of emission covered by the chamber in cm^2. Daily emission values were calculated as follows: with the six samples taken during the day at different time intervals, the corresponding fluxes were obtained using equation 1. Then, the flux values were plotted against the middle value of the time intervals; these points were joined by straight lines. The area limited by this line and the lower and upper time limits gives the total emission during the sampling time. This area was calculated by the trapezoidal rule. Then, these emissions were divided by the entire time span between the lower and upper time limits. This gave us the daily averaged flux by the application of the theorem of mean values for integrals. This procedure was designed to avoid calculation errors produced by simple averaging of the obtained fluxes.

The production of N_2O is related to water content in the soil and therefore, the percentage of soil water needed recording. WFPS gives a clear idea of the percentage of porous space of the soil occupied by water, which is directly related to the content of oxygen. The WFPS value was obtained from the content of water in the soil, soil bulk density and total porosity of the soil according to the following equations:

$$WFPS = \frac{\left(soil\ gravimetric\ water\ content \times bulk\ density\right)}{porosity} \tag{2}$$

$$Porosity = 1 - \left(\frac{bulk\ density}{2.65}\right) \tag{3}$$

To obtain seasonal nitrous oxide flux from point measurements under specific meteorological and soil conditions, the farming season was classified in several types of days (Williams *et al.*, 1998; Donoso *et al.*, 1993; Veldkamp *et al.*, 1997; Wolf and Russow, 2000) and weighted averages estimated as follows:

$$\bar{F} = \sum \overline{f_i} W_i \tag{4}$$

$$W_i = \frac{\sum d_i}{D_{tot}} \tag{5}$$

Where $\bar{F}$ is the seasonally averaged flux, $\bar{f_i}$ is the daily averaged flux of a given day type (d_i) such as dry, fertilised dry, after irrigation, fertilised and irrigated, at full capacity, etc. D_{tot} is the total number of days during the farming season counted from seeding to harvest, and W_i is the weighting factor for that type of days.

As an example of the way to obtain the seasonal flux average, the number of days of each type was estimated as follows for El Teñhé, Hidalgo: four irrigated periods without fertilization were considered to last 75 days. Irrigated and fertilized with urea, lasted 14 days. There were two periods of dry days without fertilization lasting 66 days altogether.

4. Results and discussion

In both States, the fields were under extreme drought, followed by heavy rains caused by “El Niño” event in 1998.

a. Irrigated wheat in El Teñhé, Hidalgo

Sowing was done at the end of December 1997; afterwards the land was irrigated but not fertilized. We were given notice too late, so that the measurements did not start until February 1998 just after the second irrigation. Within the same field the samples were taken from two sites separated by 50 meters. A third half-chamber was lost to vandalism. The soil water content was 51% (WFPS of 60%) and the content of organic matter was 3.5%. Soil pH and the content of organic matter showed little changes from sample to sample during the farming cycle. In March a third sampling site was included to replace one lost to vandalism. During the sampling period (February-May), the samples were taken under highly variable soil water content and ambient temperatures. Solid urea was applied on March 6, once in an equivalent dose of 80-kg N ha^{-1} before the third irrigation. This field acted as a sink of N_2O in 31% of the samples. Nitrous oxide fluxes ranged from -484 µg N_2O-N m^2 h^{-1} for high soil water content (WFPS of 70%) to 385 µg N_2O-N m^2 h^{-1} for WFPS of 76%. The seasonal nitrous oxide flux was -10.85 µg N_2O-N m^2 h^{-1} for this fall-winter cycle (December to May). This field was irrigated four times during the farming cycle: after sowing, in the last week of February, after fertilization in the middle of March, and in the last week of April (Fig. 1).

b. Irrigated maize in Progreso, Hidalgo

In March, the drought associated with “El Niño” was declared. In spite of reliance on residual water from Mexico City, irrigation water was rationed. This field was dry seeded by the middle of

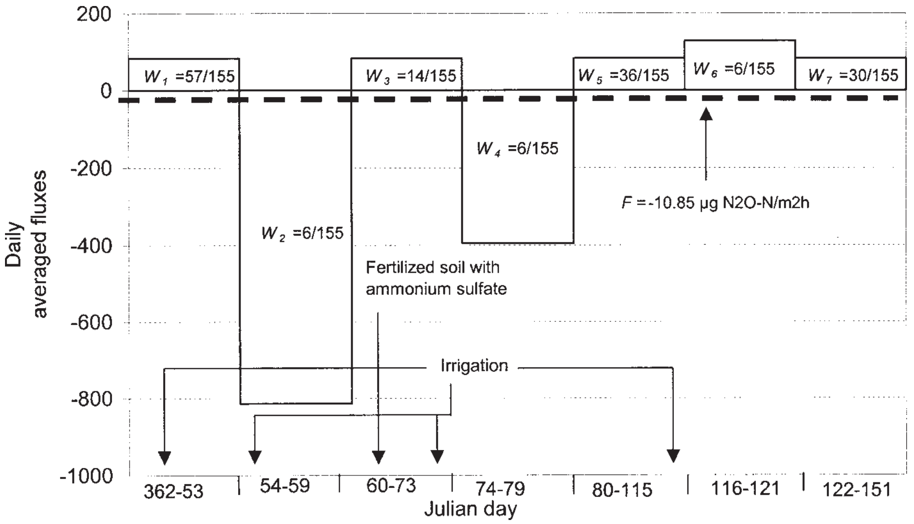

Fig. 1. Seasonally averaged flux ($\bar{F}$) with daily averaged fluxes ($\bar{f_i}$) and weighting factors (W_i) in "El Teñhé", Hidalgo. X-axis not in scale.

March relying on the residual soil moisture (~16%). Irrigation was not allowed until eight weeks after sowing. Ammonium sulfate was incorporated at a dose of 100-kg N ha^{-1} just after seeding. A second fertilization with the same dose was applied by the middle of May between rows and mixed with the soil by plough. Irrigation was again allowed in the middle of June. Sampling started in March, two days after sowing.

In 20% of the samples, the soil acted as a sink of N_2O, and in 70%, acted as a source. This sink was observed during May, when the drought was very intense, and water for irrigation was restricted. Similar behavior of dry soil has been observed during intense drought in South Africa (Levine *et al.*, 1996). N_2O flux in this field ranged from -63.82 µg N_2O-N m^2 h^{-1} (WFPS of 46%) to 86.24 µg N_2O-N m^2 h^{-1} (WFPS of 52%) (Table 3). In November, after harvest and without irrigation, negative emissions (-19 µg N_2O-N m^2 h^{-1}) were again obtained. However, it needs to be pointed out that even when sites M1 and M3 show positive and negative fluxes, site M2 only shows positive fluxes. A possible explanation could be that the field shows a slight slope, and site M1 is in the upper part of it. Irrigation is done by flooding, as irrigation water was rationed due to "El Niño", the upper site M1 never got the water content needed to trigger N_2O emissions. The seasonal nitrous oxide flux for this field under such extreme conditions was 37.43 µg N_2O-N m^2h^{-1} (Figs. 2 and 3).

c. Rainfed fields in Tlaxcala (wheat and maize)

A small, dry watercourse separates the maize and wheat fields. Emissions were only slightly higher in the case of maize. We report and discuss them together.

Table 3. Nitrous oxide fluxes measured in a maize field with irrigation, Progreso, Hidalgo, Mexico.

Sampling date	Site	Air temp. (^{o}C)	WFPS (%)	Flux (μg N_2O-N $m^{-2}h^{1}$)
19/3/98	M-1	20	20.3	32.85
19/3/98	M-2	27	20	18.12
20/3/98	M-2	28	20	10.69
29/4/98	M-2	30	18	6.48
30/4/98	M-1	26	18	-24.83
30/4/98	M-2	29	17	67.15
14/5/98	M-2	33	10	17.04
14/5/98	M-1	29	10	-15.57
18/5/98	M-1	26	52.7	3.5
18/5/98	M-3	29	54	9.49
19/5/98	M-3	29	60	2.49
19/5/98	M-2	25	53	1.45
20/5/98	M-1	31	46	-63.82
20/5/98	M-3	31	50	15.665
17/6/98	M-2	30	45	3.34
17/6/98	M-2P	32	45	7.21
17/6/98	M-3	26	55	0.285
18/6/98	M-3	26	52	86.24
18/6/98	M-2	29	43.5	1.585
18/6/98	M-2P	29	43.5	7.58
19/6/98	M-2P	25	44	0.615
19/6/98	M-1	27	42	16.52
8/7/98	M-2	20	37	6.795
8/7/98	M-3	23	43.6	2.335
10/11/98	M-2	25	37	19.15
11/11/98	M-3P	21	49	12.44
12/11/98	M-3	23	45	4.005
12/11/98	M-3P	24	50	-19

Note. M-1, M-2 and M-3 represent the number of the site sampled with one of three stainless steel chambers. M-1P represents the same site sampled with a plastic chamber.

With soil water content of 0.8% (WFPS of 2%) the maize field was sowed by the end of June, four weeks later than usual, using a fast-growing variety. It is an ancient practice of inhabitants of this region to sow maize in dry soils. Seeds do not germinate then, but with the first precipitation,

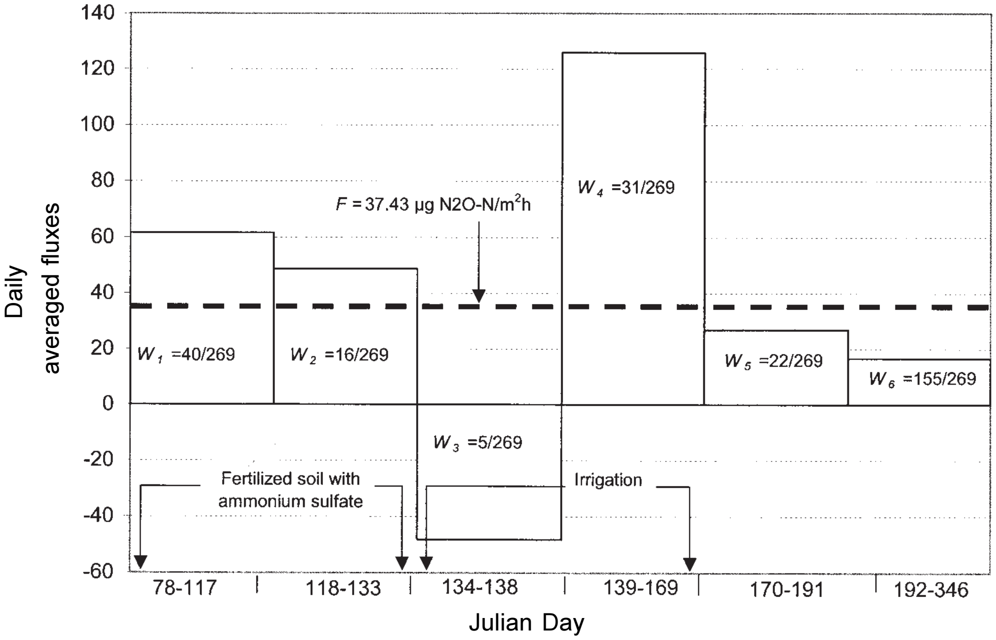

Fig. 2. Seasonally averaged flux ($\overline{F}$) with daily averaged fluxes ($\overline{f_i}$) and weighting factors (W_i) in "El Progreso", Hidalgo. X-axis not in scale.

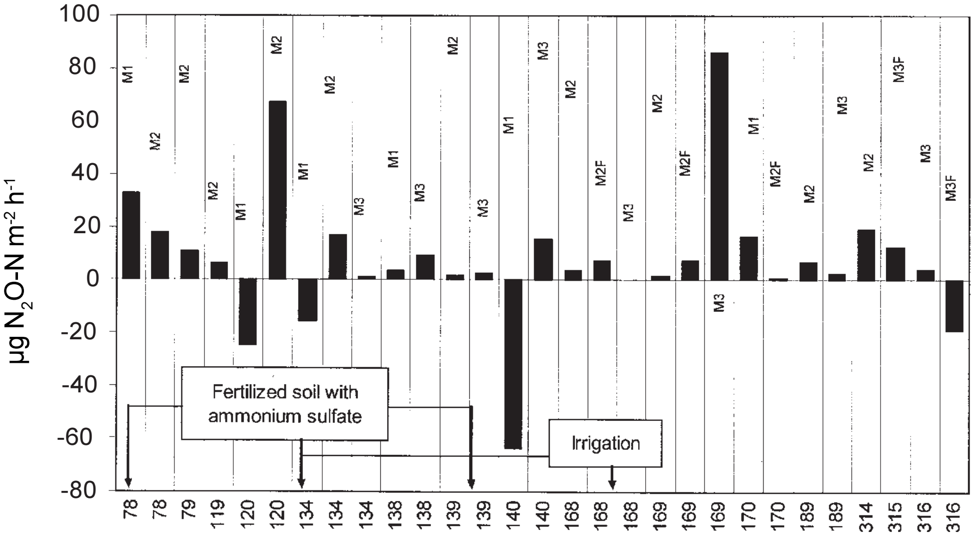

Fig. 3. Emissions of N_2O in "El Progreso", Hidalgo in 1998.

they do. After the rains started wheat was sowed in the first week of July. Sampling started the second week of July, although some preliminary samples were taken in March (dry conditions) at the time of choosing the sites. Both fields were fertilized in July and August with solid urea equivalent to 40 kg of N per hectare in each occasion. In both fields the average content of organic matter is less than 1.3% (Table 2).

Analyzed samples showed that these fields acted as emitters. Due to intense and frequent rains from September to the first half of November, access to the fields for carrying out regular and opportune sampling was not always possible. We continued the measurements until the beginning of December when the wheat and maize were going to be harvested.

The N_2O flux ranged from 3.06 µg N_2O-N m^2 h^{-1} to 551.12 µg N_2O-N m^2 h^{-1}. The two fields behaved similarly following the rainy season. From March to June, during intense drought, the fields did not emit; from June to September we measured emissions related to fertilization and precipitation. The seasonal flux was 121 µg N_2O-N m^2 h^{-1} for the wheat field, and 285.61 µg N_2O-N m^2 h^{-1} for the maize field (Table 1).

5. Conclusions

Local nitrous oxide fluxes were measured for two crops (maize and wheat) with a reliable methodology under severe drought and later, under sustained and heavy rains related to the strong “El Niño” in 1998. The original sampling schedule had to be changed for this reason and fewer samples than expected were taken. Nevertheless, we believe that the measurements done may contribute to the knowledge on nitrous oxide emissions under extreme conditions such as those produced under the effects of strong “El Niño” events. To verify obtained high negative flux values, it will be necessary to repeat our measurements under similar extreme climatic conditions (i.e. another “El Niño”).

Farming in the rain fed fields of the state of Tlaxcala started under intense drought. In addition, due to water rationing soil in the maize field in Hidalgo, fields had very low water content during the first part of the crop cycle. Similar behavior of dry soil has been observed during an intense drought in South Africa (Levine *et al*., 1996).

Like other authors (Teira-Esmatges *et al*., 1998), we found that once the long delayed rains started, the fields with low content of organic matter (~ 1.3%) in Tlaxcala showed high emission rates. In contrast, those sites containing 3.5% or more of organic matter showed lower emission rates, as in the state of Hidalgo. Unusual high negative fluxes were observed indicating the need for further studies considering soil water content, fertilizer type, organic matter and other soil properties. Nevertheless, other authors in different parts of the world have observed emission values similar to those seasonal fluxes obtained here.

These results show that reliable emission inventories of N_2O in agricultural systems require deeper soil characterization and consideration of climatic conditions at the sites. Extreme conditions (intense drought and intense rain) caused by “El Niño” have influence on N_2O emissions.

Acknowledgements

This work was supported by UNEP/GEF under contract MEX/95/G31/A/IG/99 with the National Institute of Ecology (INE). We wish to thank to Mrs. Julia Martínez at INE, for all her support and assistance. To Mr. Rubén García Silva and Mr. Andrés María Ramírez and the Head Office of the Region Center of the National Institute of Forests Agricultural and Livestock Investigations (INIFAP) for their help on choosing the fields and getting permission from the farmers to carry out our sampling. To Mr. José Manuel Hernández Solís for his support in the GC laboratory and to Mr. Alfredo Rodríguez for his collaboration in the construction of the sampling chambers.

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