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Workshop on Nitrogen Cycling in Ecosystems of Latin America and the Caribbean

16-21 March 1981

CIAT

Cali, Colombia

Participants and Abstracts

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ABSTRACTS

Rosswall -

1975 - N cycling of terrestrial systems

Regional Workshops
1978 - IITA Nigeria
1979 - Chiang Mai - Thailand - training - Bangladesh 2nd, 1981
1981 - CIAT - Colombia — " Jamaica UWI ? 1982

a) collect information

b)

c) identify gaps

d) training

e) monitoring nitrogen

f) contribute to MAB projects

D. Sanaricenti - UNEP

Plant assimilation and nitrogen cycling

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Nitrogen, the most abundant and yet most limiting nutrient for crop and food production enters the plant as nitrate or ammonium, or as dinitrogen through biological fixation by procaryotes associated with the plant. Incorporation of N into the soil-plant-animal system is restricted to biological and industrial fixation. The first is energy conserving; the second is preferred in most present agriculture. Research on nitrogen metabolism has the practical objective of utilizing N fertilizer more efficiently in plants not able to grow on N_2, or complementing biological nitrogen fixation when justified.

We will limit our discussion of basic reactions of N in the soil, emphasizing processes leading to uptake or loss, effects of temperature, water content, pH, organic matter and aeration, the rate of N turnover, and problems of recovery and prediction.

Uptake and assimilation of N by plants will be discussed in more detail. Pathways will be traced and related to uptake and assimilation kinetics, seasonal patterns, and the plant efficiency of N assimilation. Emphasis will be placed on legume growing on both nitrate and N_2, and the energy balance involved.

Nitrogen accumulation by harvested crops leaves a net input into the soil of base or acid, depending on the source of N. Because there is little information on long term effects of crop N nutrition on acidity, and acidity is already critical in many tropical soils, emphasis will be given to plant control of pH and the acid/base balance in the soil as a consequence of N uptake and assimilation.

Rosswall Can NR (nitrate reductase) be used to measure NO_3^- uptake by plants? Franco - No, the enzyme is saturated at very low levels of nitrate,

Holding Translocating nitrogen

Assimilação pelas plantas e ciclos do nitrogênio.

O nitrogênio, apesar de ser o mais abundante é ao mesmo tempo o nutriente que mais limita a agricultura e a produção de alimentos. Sendo absorvido como NO_3^-, NH_4^+ ou N_2 em certas plantas com o auxilio de procariotes. A incorporação de N no sistema solo-planta-animal é restrita basicamente a fixação biológica ou industrial. O primeiro processo conserva energia fossil; o segundo é geralmente o preferido na agricultura tradicional. O estudo do metabolismo do nitrogênio, tem como objetivo prático, o uso mais eficiente dos fertilizantes nitrogenados pelas plantas não capazes de crescer em N_2, ou complementar a fixação biológica, quando tecnicamente ou economnicamente for apropriado.

Nossa discussão será limitada às reações básicas do N no solo, com ênfase nos processos ligados à disponibilidade ou perdas, efeitos de temperatura, umidade, pH, matéria orgânica, taxa de mineralização, problemas de aproveitamento e testes analíticos.

A absorção do solo e assimilação de N pela planta será discutido mais detalhadamente, incluindo variação com o ciclo vegetativo; o caso específico das leguminosas crescendo em nitrato e N_2 e o balanço energético envolvido.

A acumulação de nitrogênio na parte da planta removida do sistema durante a colheita, deixa um saldo de base ou ácido, dependendo da fonte de N. Devido a pouca informação sobre estes efeitos a longo prazo e a acidez ser um fator critico em muitos solos tropicais ênfase será dada no controle do pH na planta e no balanço ácido/base no solo como consequência da assimilação de N.

Microbiology of Nitrogen Transformations

T. Rosswall

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Ecosystem (1) describe
(2) Name
(3) Count x biomass = activity

Microbiology - what's in a name?
describe processes and rate
" mediates most of N transformation
hence, microbiology is here

Plants - 94 % - decay
Microbes - 4 %

Mineralization ≠ immobilization
emphasized the N efficiency of microbes

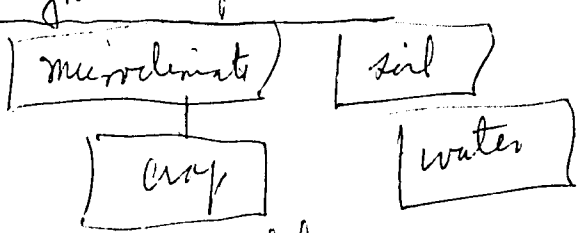
Inorganic cycling -

RaO - Modeling

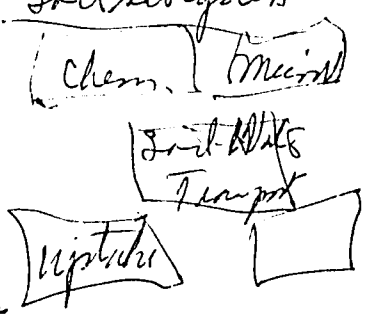
Objectives

1. Logical synthesis of existing knowledge
2. Provide direction for future research
3. Quantitative

Agro-ecosystem



Soil subsystem



Factors in a model

1. Conceptual completeness in No. system
2. Level of detail of each system

Factors influencing Model

1. SOTA
2. Modeller's conceptualization
3. " approach
4. Acceptable error bounds
5. Spatial and temporal scales

Application of Models

1. Research - oriented
2. Management - "
3. Planning - "

Outputs = Inputs + change in storage at steady state

Model selection criteria

1. Intended use
2. Spatial + temporal scales
3. Availability of computational facilities
4. Availability of input data
5. Confidence regions on input and output

N-balance

Cost $ 3000 — I — II — III - last $3

Mineralized N
Fert N
Cumulative Plant uptake
Mineral N in soil profile
Cumulative Outflow

THE ROLE OF THE ATMOSPHERE IN NITROGEN CYCLING

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SUMMARY

In this work an analysis of the sources, atmospheric concentration, chemical reactions and sinks of the principal atmospheric nitrogen compounds is made. A nitrogen balance for the troposphere is presented. Using the photochemical mean residence time of NO_x, the atmospheric dispersión processes and the tropospheric water cycle, the role of the atmosphere in nitrogen cycling is discussed.

RESUMEN

En el presente trabajo se hace un análisis de las fuentes, concentraciones, reacciones químicas y depósitos de los principales compuestos nitrogenados atmosféricos. Se plantea un balance del nitrógeno troposférico. Basándose en la vida media fotoquímica de los NO_x, los procesos de dispersión atmosférica y el ciclo troposférico del agua, se discute el papel que cumple la atmósfera en los ciclos terrestres del nitrógeno.

	Reservoir	Fixation	
N_2	78×10^4		
NH_3	6×10^{-3}	Biol + Ind	305×10^6 T/yr
N_2O	3×10^{-1}	Rainfall	(?) $200 + \times 10^6$ T/yr ?

Contribution of N from atmosphere -
Rainfall - very important
Tundra - more in rain than BNF

Estimates of the Role of Animals in Nitrogen Cycling

Norman R. French

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Animals, both vertebrate and invertebrate, play an important role in the cycling of nutrients in ecosystems and may be of significance in providing a stable source of nutrient supply in tropical ecosystems. Chemical composition of surface soils are modified by herbivores, resulting in alteration of the nitrogen content (Taylor 1935), modifying the availability of phosphorus (Greene and Reynard 1932) by altering the CO_2 concentration, which in the burrows of subterranian forms may be 60 times higher than normal (Kennerly 1964), and through burrowing by bringing elements such as silicone, iron, aluminum, calcium and magnesium to the surface layers (Abaturov 1972). The manifold effects of defoliation on microclimatic conditions, decomposition, nutrient cycling and total system production has been evaluated by Zlotin and Khadashova (1974). The impact of burrowing mammals on surface soils can be estimated from the fact that between 7 and 28 tons of deep soil is brought to the surface per year per acre (Buechner 1942, Thorp 1949), and that 36% of the surface is covered by such mounds of moles in Eastern Europe (Abaturov 1968).

Herbivores generally assimilate half or less of the materials they ingest. Feces decompose more rapidly than plant litter, and the addition of frass to litter augments litter decomposition processes. Nutrients are redistributed by the mechanical activities of animals, and by passing through the gastro-intestinal tracts of herbivores. Small mammals are known to control local concentrations of nutrients at high latitudes, particularly phosphorus, calcium, and nitrogen, and to affect seasonal cycles of these nutrients by clipping of standing dead material and depositing large amounts of urine and feces. High productivity of vegetation around small mammal burrows and harvester ant mounds in the shortgrass prairie is partly due to nutrient accumulation and partly due to increased infiltration.

A striking effect of animals on plant establishment has been demonstrated in the role of rodents in dissemination of hypogeous fungi, which play an important role in plant absorption of soil nutrients through ectomycorrhizae. Mycorrhizae have been found on the roots of most families of the world vascular plants. Many of these are dependent on mycorrhizae for nutrient uptake. Fruiting bodies of such fungi have been found in the stomach contents of at least 29 species of small mammals, from temperate grasslands to tropical savanna, which animals play a critical role in the dispersal of mature spores throughout certain ecosystems. (Maser, et al. 1978).

In Neo-tropical ecosystems sloths return nutrients near the boles of trees on which they forage, and decomposition of these feces proceed slowly, providing a stable source of nutrients (Montgomery and Sunquist 1975). Plant roots tap these sources of nutrients (Odum 1970). Such slow rates of flow result in more stable ecosystems (Jordan et al. 1972). Leaf-cutting ants also provide concentrated nutrient sources (Haines 1975).

Although there are few species of large herbivores in the Neo-tropical region, causing some zoogeographers to classify the region as unsaturated, there is a large and diverse fauna of small herbivores. These can easily compensate for the shortage of large herbivores due to their higher energetic requirements as a result of the allometric relationship between energy and body size. These include hares (Patagonian and *Pediolagus*) and large rodents such as the nutria and the viscacha. The burrowing tuco-tucos (*Ctenomys*) are much larger than northern temperate burrowing mammals and have a huge capacity for moving masses of soil. There are at least 8 genera of cricetine rodents and as many caveomorph rodents in the Neo-tropical region. With adequate biomass estimates, their impact on ecosystem structure and nutrient cycling could be approximated.

Maximum yields available now

Can support more people on cereal grain	Soybean	5.6	15.8	Kg/ha D.M
	% N	6.1	2.2	" "
	N content	340	350	" "

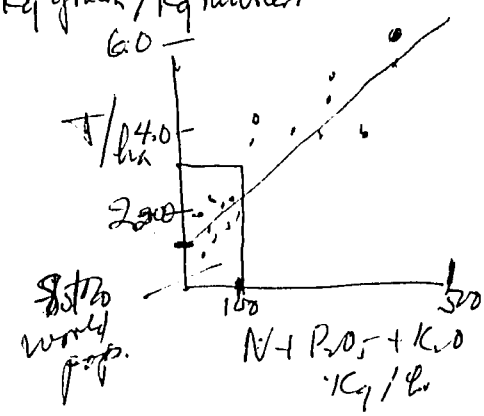
Rate of D.M/ha/day ≈ 0-2T/ha/day C3 crops
adequate feed, water, etc.

	Crop reqt	U.K soil
N Kg/ha	300	40
P_2O_5	60	10
K_2O	300	55

100,000 trials by FAO

Cereals

	yield inc. Kg grain/Kg nutrient
N	12.7
P_2O_5	10.3
K_2O	2.6
Value cost ratio	4.8



Fertilizer N used very poorly

Prefers mechanistic or modelling methods to statistical (soil test?) method
(trials)

Recycling of N in Agr very small

27% of N in grass lost in haying
30% lost in ideal compost
50% of animal excreta
90% of human excreta

Legumes can fix 300 or more kg N/ha

(1) Establishement
(2) Grain legumes inherently lower yield.

Fertilizer nitrogen, biological nitrogen and crop yield : global scene

D.J. Greenwood

National Vegetable Research Station, Wellesbourne, Warwick, U.K.

Yields almost everywhere are limited by acute deficiencies of at least one major nutrient. Responses to fertilizer are invariably considerable and average yields per ha of cereals (the main component of man's food) in the major countries are almost proportional to the amounts of N + P_2O_5 + K_2O applied as fertilizer. In West Europe where the soils are well endowed with P_2O_5 and K_2O yields of wheat are nearly proportional to the level of N fertilizer.

Much N fertilizer is wasted because of difficulties in forecasting how to adjust levels and methods of application for differences in conditions. Predictions based on statistical interpretation of the results of field trials have proved to be unsatisfactory. The new 'mechanistic' or 'modelling' approaches that take far greater account of existing principles about key processes have been more successful.

Much scope exists for saving N fertilizer by adopting practices that improve the re-cycling of nutrients and increase biological N-fixation. Although legumes can yield as much dry matter as nitrate fed plants, seed yields are inherently much lower than those of cereals.

Sufficient N fertilizer to grow all the food required for mankind can be synthesised from only 2% of the present world consumption of fossil fuel. Despite massive increases in oil prices the cost of nitrogen fertilizer relative to that of food has remained virtually unchanged. It is still very profitable to apply nitrogen fertilizer in most parts of the world.

The most serious problems in the future are likely to result from essential resources (energy and minerals) being very unevenly distributed in relation to where they are needed to grow food.

25% 64,000,000 TN to support entire world pop

	t/yr
Total fossil fuel	7×10^9
all fert N	0.1×10^9
Hydroelectric power	

Wheat/urea N has remained constant over past 10 yr.

Reserves

Oil	56%	Middle East
P_2O_5	70%	Morocco
K_2O	77%	Canada

Fertilizer use has increased in developing countries by 10

Says man ~~can eat~~ needs only food w/ 0.7 Kg of 1% N/day to survive

Maize ≃ 0.8 to 0.9% N

Rice

Wheat ≃ 1.4 % N

Nitrogen Cycling in Amazonian Rain Forests

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Os Ciclos do Nitrogênio nas Savanas Sulamericanas

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NITROGEN CYCLING IN COFFEE PLANTATION

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This system requires for its adequate functioning considerable inputs of nitrogen as it loses yearly in the crop some 20 to 50 Kg ha^{-1} of N. Pruning of the coffee and eventually of the shade trees results in N loses also which can be estimated in about one half of the N estracted by the crop. In well estabhished coffee plantation with shade or without shade but with a high plant density (7000-8000 plants ha^{-1}) run-off is slight, but percolation is serious as coffee is often grown on high porosity soils. Coffee soils usually present also favourable conditions for nitrification, unless they are too acid, and favour so nitrate formation and loss as this anion is weakly retained even in high surface volcanic soils. It is estimated, but no data are available, that gaseous loses of N from the coffee system are quite small as soil temperature is moderate, pH acid and humidity adecuate through a large part of the year.

The main N entry in the system is represented by chemical fertilizers which amount to 200 to 300 Kg ha^{-1} yr^{-1}. Organic matter mineralization is and additional source of importance, particularly if farm yard manure, crop residues or mulches are used, and the soils are not allophanic. Symbiotic fixation by some leguminous shade trees as some Inga species can add up to 40 Kg. ha^{-1} yr^{-1}. of N as shown by recent Mexican work.

Weeds take up N but are returned to the soil and as such represent a closed branch of the system whic ties up N but does not cause a loss of it.

NITROGEN CYCLING IN SUGAR CANE

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Sugar cane was introduced into northeastern Brazil in the 16th century but has been extensively grown in all regions for the last seventy years. Fertilizer N, usually as $NaNO_3$, has been applied only since the 1940's but yield response has been small.

Yields of sugar cane average 70 tonnes/ha.year(average of four cuttings) with the first cutting 1 1/2 year after planting followed by ratoon cuttings in subsequent years. The nitrogen content of sugar cane is low, averaging 35 kg N/ha. From these yield figures, nitrogen cycling under sugar cane agriculture is discussed. The following assumptions are made: 1) Most Brazilian soils contain 0.05%N and mineralize 50 kg N/ha.yr of which 50% is taken up by the plant. 2) The fertilizer use efficiency of sugar cane is approximately 30%. 3) Nitrogen returned to the soil in the form of sugar cane residue has a high C/N ratio and is not significant in relation to the total pool mineralizable soil N. Two cases are presented (Table 1), unfertilized and fertilized sugar cane fields.

Table 1. Tentative nitrogen balance in fertilized and unfertilized sugar cane agriculture (kg N/ha.yr).

Nitrogen Source	Unfertilized	Fertilized
Plant Yield	35	45
Soil	25	25
Fertilizer	0	15
Fixed	10	5
Returned	14	21

The importance of alcohol production from sugarcane has instigated programmes stusying soybeans in rotation with sugar cane that is intercropped with common bean (*Phaseolus vulgaris L.*). Assuming that 575,000 ha are planted to sugar cane each year in Brazil, the amount of N_2 fixed per annum based on ^{15}N data is 74 kg N/ha composed of 5.9 kg N from associated N_2 fixation with sugar cane and 49.0 and 19.1 kg N/ha from the symbiotic N_2 fixation with soybeans and common beans respectively. This cropping sequence returns 87.96 kg N/ha each year to the soil, 13.76 from sugar cane, 53.40 from soybeans and 20.8 from common beans.

Isotopic studies using ^{15}N at levels of natural abundance have indicated that different sugar cane varieties support different amounts of associated N_2 fixing activity in the roots.

Nitrogen Cycling in maize-legume Production Systems

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Discussed data on maize and bean and intercropped. Generally, more negative results than positive results. Very little direct transfer.

Discussion -

Glissman - need ~~longer~~ varieties of long association.

Results look more promising.

Nitrogen Cycling in Relation to Shifting Cultivation

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Presented data on shifting cultivation based primarily on Yurimaguas, Peru data.

SIMULATION OF NITROGEN BEHAVIOR IN AGRO-ECOSYSTEMS: CRITERIA FOR MODEL SELECTION AND USE

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An overview of simulation models for describing nitrogen behavior in agro-ecosystems is represented. The available simulation models vary in two characteristics: (*i*) conceptual completeness in terms of the number of processes considered, and (*ii*) the level of detail at which each process is modeled. Both of these model charcteristics are determined by the objectives in development of the model and the state-of-the-art in understanding the various processes included in the model. The levels of conceptual completeness and detail in a model govern the potential application in which the model may be used. Applications of models may be research-oriented, management-oriented, or planning-oriented. A model suitable for a given application should have an appropriate level of completeness and detail to accomplish the stated objective.

Criteria are suggested to aid in selection and evaluation of nitrogen simulation models for a particular application. Emphasis is placed on identifying the critical elements of the simulation model which should influence the selection of a model. These include: availability of computational facilities, intended use of the simulations, spatial and temporal scales of application, availability of model input data, and the confidence regions associated with the model output. An example is presented which demonstrates the utility of the above seleciton criteria for choosing a model for managing irrigation and fertilizer inputs for a corn crop in Florida, a semi-tropical humid ecosystem.

Nitrogen Cycling in an Amazonian Black Water Inundation Forest

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Based on litterfall and litter samples and degradation experiments with cockroaches a nitrogen cycling approach for an Amazonian black water inundation forest is tried. It can be shown, that saprophagous arthropods, in spite of their relatively low abundance play an important role within the nitrogen cycling. They increase the nitrogen concentration in the feces and decompose 1/3 of the total nitrogen decomposition during the emersion phase.

ASPECTOS DEL CICLO DEL NITROGENO EN EL MATORRAL PRECORDILLERANO DE CHILE CENTRAL.

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Se analiza la dinámica del Nitrógeno en Lithraea caustica y Quillaja saponaria, dos de las especies dominantes del matorral pre-cordillerano de la zona Central de Chile. El aporte de este nutriente al sistema a través del agua de lluvia se estimó en 9.2 Kg/ha/año, lo que equivale al 50% del nitrógeno que se suministra a un cultivo de trigo a través de fertilizantes. Sin embargo, la cantidad que realmente llega al suelo es de 8.41 Kg/ha/año. La retención de este elemento esencial en el follaje de ambas especies es de 790 g/ha/año. Esta deposición de nitrógeno al suelo en el agua de lluvia ocurre preferentemente durante los meses de Mayo a Septiembre debido al régimen pluviométrico mediterraneo de la región.

La cantidad de nitrógeno en el follaje de estas especies fluctua estacionalemente alcanzando valores máximos de 1.03 % y 1.15 % para L. caustica y Q. saponaria respectivamente. Ambas especies se caracterizan por una activa movilización de nitrógeno hacia otras estructuras de la planta previo al desprendimiento de las hojas muertas. Este mecanismo conservador de nitrógeno parece ser más eficiente en L. caustica que en Q. saponaria. La liberación de nitrógeno mediante la descomposición de la hojarasca es dos veces más rápida en Q. saponaria que en L. caustica.

Se postula, a modo de hipótesis, que ambas especies representarían estrategias distintas en la conservación y movilización del nitrógeno en este ecosistema. Por una parte, L. caustica minimizaría la liberación de nitrógeno al suelo y maximizaría la circulación interna de este elemento. Por el contrario, la descomposiciónde hojarasca representaría la mayor fuente de nitrógeno para Q. saponaria adquiriendo el ciclado externo de este elemento una gran importancia.

Se discute además, las implicancias ecológicas para el resto de la comunidad de estas dos estrategias en la movilizacion de este elemento esencial. Se incluyen ciertas evidencias acerca de las alteraciones del ciclo del nitrógeno producidas por efecto del fuego.

Aspects of the Nitrogen Cycle in the Chilean Matorral Zone

R. Cisternas and L.R. Yates

We analyzed the dynamics of nitrogen in Lithraea caustica and Quillaja saponaria, two of the dominant species in the matorral zone of central Chile. Input of this nutrient to the system in rainwater is 9.2 kg ha^{-1} yr^{-1}, equivalent to 50% of the nitrogen supplied to wheat by fertilizers. However, the quantity that actually reaches the soil is 8.41 kg ha^{-1} yr^{-1}. The retention of this essential element in the foliage of both species is 790 g ha^{-1} yr^{-1}. This deposition of nitrogen to the soil in rainwater occurs mainly during the months of May-September as the climate is Mediterranean.

The quantity of nitrogen in the foliage of these species fluctuates seasonally, reaching maximum values of 1.03% and 1.15% for L. caustica and Q. saponaria respectively. Both species are characterized by an active mobilization of nitrogen to eight structures of the plant before abscission of the dead leaves. This mechanism of nitrogen conservation seems to be more efficient in L. caustica than in Q. saponaria. The release of nitrogen by litter decomposition is two times faster in Q. saponaria.

It is hypothesized that both species should represent different strategies in the conservation and mobilization of the nitrogen in this ecosystem. On the one hand, L. caustica minimizes the liberation of nitrogen to the soil and maximizes the internal circulation of this element. On the other hand, the decomposing foliage represents the major source of nitrogen for Q. saponaria, giving the external cycle of this element a great importance.

We discuss also the ecological implications for the rest of the community of these two strategies in the mobilization of this essential element, including certain evidence concerning alterations of the nitrogen cycle by fire.

Fijacion de Nitrogeno en Ambientes Inundables

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Se han aislado bacterias fijadoras de nitrógenoâ no simbióticas, de la interfase suelo-agua de ambientes inundados. El aislamiento recién fue posible después de agitar enérgicamente el agua hasta adquirir turbiedad por contener suelo en suspensión. Esto nos hizo suponer que la población fijadora de nitrógeno se encuentra en la interfase suelo-agua. Las bacterias aisladas aon del género Azotobacter predominando el A.agilis y en menor proporción el A. crococcum, diferenciándose estas especies por la pigmentación y por la movilidad.

Además se ha verificado en las mismas suspensiones de agua-suelo el proceso de nitrificación. La presencia de estos dos procesos, nitrogenación y nitrificatión, justifican cualitativamente la existencia de pastizales y da vegetación acuática.

Las fuentes de carbono utilizadas fueron además de manita, alcohol, acetato de sodio en forma de "cocktail" por desconocer la selectividad de estas poblaciones.

Los lugares estudiados no tienen flora de leguminosas de ambientes inundables que permitan pensar in una realimentación nitrogenada por via simbiótica.

Estos resultados llevaron a Soriano y Molina a estudiar la fractura de la celulosa en condiciones anaerobias, en cultivos puroså determinando que sus subproductos funcionan como insumos energéticos de los fijadores no simbióticos.

También se han aislado algas del genero Anabaena en medios altamente selectivos de silica gel y carbonato de calcio.

N-Fixation in Wetlands

Pedro Fuentes Godo

We have isolated nonsymbiotic nitrogen-fixing bacteria from the soil-water interface of flooded environments. The isolation was possible after vigorous agitation of soil suspended in water. We assume the population of nitrogen-fixers so-encountered represent those in the soil-water interface. The isolated bacteria are of the genus Azotobacter, predominantly A. agilis and to a lesser extent A. crococcum, differentiating these species by pigmentation and mobility.

Moreover, we have verified in the same suspensions the process of nitrification. The presence of these two processes, nitrogenación and nitrification, allow the existence of pasture and aquatic vegetation.

The sources of carbon utilized were además de manita, alcohol, and sodium acetate in the form of a cocktail which allowed selection of these populations.

The study sites had no leguminous plants that could provide significant amounts of symbiotically-fixed nitrogen.

These results brought Soriano and Molina to study the breakdown of cellulose under anaerobic conditions in pure culture, who determined that the subsequent byproducts could function as an energetic substrate for the nonsymbiotic nitrogen fixers.

In addition, we have isolated algae of the genus Anabaena in a selective medium of silica gel and calcium carbonate.

Algunos elementos para cuantificar el ciclo del nitrógeno en ecosistemas de sabanas tropicales de los llanos de Venezuela

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THE NITROGEN CYCLE IN A "TIERRA FIRME RAIN FOREST ON OXISOL IN THE AMAZON TERRITORY OF VENEZUELA

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Standing stocks and fluxes of nitrogen, including nitrogen fixation and denitrification, were measured in a tropical rain forest on oxisol in the Amazon Territory of Venezuela. Standing stock of nitrogen was comparable to that of temperate forests, but was higher than that in an adjacent forest on spodosol. Fluxes were higher than in forests in the temperate zone, but lower than in another tropical forest on more fertile soil. This Amazon forest seems to be less conservative of nitrogen than of other elements. However, this does not mean that nitrogen could not be limiting to agriculture, if the forest is cleared and the land cultivated. The nitrogen fixing and nitrogen conserving mechanisms are dependent upon the structure of the undisturbed forest, and destruction of the forest would eventually decrease the input of nitrogen to the soil.

Nitrogen cycling in the seasonally dry forest zone of Belize, C. A.

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Two forest associations, Cohune Palm (Cohune Ridge) and mixed hardwood (High Bush) were assessed on the basis of nutrient movement and storage for their suitability for agriculture. Continuous monitoring of soil nitrogen and leaf litter nitrogen were completed over a two-year period providing information on soil building processes of forest fallow.

Destructive cuts were made to determine nutrients held in the standing biomass. On the basis of such data the suitability of selected forest associations were assessed and compared.

Seasonal Dynamics of Nitrogen Cycling for a *Prosopis* woodland in the Sonoran Desert.

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Intensive studies of *Prosopis glandulosa* in the Sonoran Desert have demonstrated the dramatic impact of *Prosopis* on patterns of ecosystem nitrogen cycling. Of particular significance are the very high levels of soil nitrogen existing under the canopies of large individuals and the apparent stability of this accumulated nitrogen. Nitrogen in the upper 60 cm of the soil has a concentration of 1020 g m^{-2} beneath the canopies of *Prosopis*. This is seven times the level between canopies and 20 times the concentration outside of the stand. The nitrate concentration in the canopy soil is 253 g m^{-2} (612μg g^{-1}), while amnonium concentration is only 5 g m^{-2}. The total above-ground plant uptake of nitrogen during 1980 was 4.71 g m^{-2} of canopy, 50% of which was allocated to leaf tissue and 25% to reproductive tissues. Abscission of leaves and reproductive tissues during the winter recycles 3.04 g m^{-2} back into the soil in litterfall. With a mean annual precipitation of less than 80 mm leaching is very minor. Inputs of nitrogen by precipitation are estimated to be more than 7.0×10^{-6} g m^{-2} canopy. Denitrification rates following heavy precipitation (5 cm) may reach as high as 0.03- 0.12 g N m^{-2} hr^{-1} for a few hours, but the rarity of events indicate that denitrification is insignificant in the overall nitrogen cycle. Amnonia volatilization is virtually absent. The major input of

nitrogen to Prosopis stands historically has been through nitrogen fixation by Rhizobium in root nodules. Since archaeological and geological evidence has demonstrated that the maximum age of the study site is 500 years, the mean annual increment of nitrogen under Prosopis canopies must be no less than 1.95 g m^{-2} over this period. Ground water tables ct 5.0 m depth provide a maximum of 0.90 g $^{-2}$ yr^{-1} of nitrogen through the transpiration stream. The remaining mean of 1.05 g $m^{-2}yr^{-1}$ must come from nitrogen fixation. Several models are presented to explain this building up of nitrogen by fixation.

Nitrogen cycling in traditional farming systems of Belize, C. A.

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Nitrogen cycling in traditional milpa agriculture in Belize was assessed. Release of nitrogen during clearing and burning was determined. Subsequently nitrogen levels were monitored for a three-year period in a corn/bean milpa to determine distribution in crop plants (root, stalk, leaves and seed) and weeds. Increasing weed biomass both during the year and throughout the study period indicate that soil nitrogen levels did not drop appreciably. Weed species controlled an increasing percentage of available nitrogen.

Data from the site, and an older farming area were compared. Recommendations regarding the period of agricultural use and fallow period were made.

Aspects of nitrogen cycling in several traditional agroecosystems in the humid tropical lowlands of southeastern Mexico.

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Nitrogen distribution is examined in the following local agroecosystems typical of the lowlands of tropical southeastern Mexico: upland monoculture corn, lowland monoculture corn, corn/bean polyculture, manioc (yuca), taro (malanga), and rice. Data for total biomass, and corresponding nitrogen content, were determined by monthly samples taken of the standing live, standing dead, and litter biomass for both crop and non-crop components of each system. The crop component was further divided into roots, crown, stem, leaves, fruits, and flowers. Corresponding soil nitrogen determinations were also made monthly. Results demonstrate that nitrogen maintenance in the system is highly dependent on the proportion of the net biomass produced which is returned to the system, as compared to the part which leaves the system in the form of agricultural yield. The importance of leguminous components or the weed component in reducing nitrogen loss for each system is discussed.

Compartamiento de dos cepas de *Rhizobium japonicum* en suelos tradicionalmente en cana de azucar (*Saccharum officinarum* L.)

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Ganancias y Perdidas de N en el Agro-Ecosystem de la Cana de Azucar de la Costa del Peru 31.

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Se realizó un análisis de las principales ganancias y pérdidas de N en campos de la zona aluvial irrigada del valle de Chicama (costa árida del Perú), de varios experimentos de campo, llevados a cabo en el Instituto Central de Investigaciones Azucareras, con el cultivar de caña de azúcar H32-8560,

En zonas con suelos normales (regados con agua de río o pozos y sin problemas de salinidad), se llegó a la conclusión de que las ganancias de N por el suelo (en una campaña de 18 meses) provienen de un aporte de fertilizantes comerciales en cantidad de 300 kg N/ha^{-1},(que es una cantidad muy cercana a la dosis óptima económica); por el agua de riego la cantidad incorporada es de 14 kg N/ha^{-1} para el agua de río y 23 kg N/ha^{-1} para el agua de pozos; y por mineralización del N de 84 kg N/ha^{-1}, haciendo un total de 398 a 407 kg N/ha^{-1}. A su vez, se determinó que las principales pérdidas de N del suelo, se deben a la extracción por la parte aérea de las plantas, la cual fue de 210 a 246 kg N/ha^{-1}. De este total se encontró que el 30 % se pierde a la atmósfera, con el quemado de la caña, o sea de 63 a 74 kg N/ha^{-1}, y el 70 % queda en la caña que es cosechada y remitida a la fábrica para su procesamiento (147 a 172 kg N/ha^{-1}). Las pérdidas de N por volatilización de la urea son nulas, cuando se aplica el abono enterrado, pero cuando la aplicación se hace en suelo seco con riego posterior, son muy bajas. Por lixiviación se pierden 12 kg N/ha^{-1}, haciendo un total de 222 a 258 kg N/ha^{-1}.

Se incluyen en el trabajo, algunos datos de ganancias y pérdidas de N en campos salinos, y en campos normales regados con agua de deshecho de la fábrica de azúcar (agua de cachaza).

GAINS AND LOSSES OF N IN THE AGRO-ECOSYSTEM OF THE SUGARCANE OF THE PERUVIAN COAST

Principal gains and losses of N in fields of the alluvial irrigated zone in Chicama valley (arid coast of Peru) were investigated, of varios experiment that were carried out by the Instituto Central de Investigaciones Azucareras, with sugarcane cultivar H32-8560.

In zones with normal soils (irrigated with river or wells water and no saline) it was found that the gains of N by the soil (in crop of 18 months) are originated by an addition of 300 kg N ha^{-1} of commercial fertilizers (quantity nearest to the economic optimum level); by irrigation water, which added 20 kg N ha^{-1} by river water and 32 kg N ha^{-1} by wells water ($\bar{X}$ of 24 kg N ha^{-1}); and by mineralization of organic N, being 139 kg N ha^{-1}, totalizing 463 kg N ha^{-1}. The principal losses of soil N, are originated by extraction of the aerial part of crop, which hold 210 to 246 kg N ha^{-1}, and by underground part (roots, rhizomes and stubble), which hold 235 kg N ha^{-1}. Of total extracted by aerial part, 30 % was lost by sugarcane burning (63 to 74 kg N ha^{-1}) and 70 % was preserved in sugarcane that was harvested and processed in the mill (147 to 172 kg N ha^{-1}). Losses of N by urea volatilization are negligible when fertilized is applied mixed with soil. Losses by leaching are 33 kg N ha^{-1}, totalizing 478 to 514 kg N ha^{-1}.

It is included some data of N gains and losses in fields irrigated with waste water of sugar mill ("cachaza-water") and in saline soils.

Effectos de Tratamientos de Barbecho en Cultivo de Maiz, en la Evolucion Dinamica de la Materia Oranica, del Nitrogeno y de Algunos Grupos Microbianos

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Se trabajó en cultivo de maíz en diseño de bloques al azar determinando: -efecto de la época de incorporación de rastrojos del cultivo anterior(labranza anticipadas de junio(J) y setiembre(S) y el día de la siembra(C) y - el efecto de implementos de labranza(arado rastra o múltiple y pie de pato,solos o en combinación con escarificador), en la disponibilidad del nitrógeno mineral,evolución de la materia orgánica y el nitrógeno y en microorganismos del ciclo del nitrógeno:Azotobacter y nitrificantes,en periodo de dos años sobre un ensayo de 4 años.

En la acumulación de nitrógeno mineral no se presentaron diferencias en el amonio y sólo en algunos períodos éstos se manifiestan en nitratos y N mineral total y solamente en el horizonte 0-20cm. Aunque estas diferencias fluctúan en la vecindad del testigo.No se presentaron problemas significativos de inmovilización del nitrógeno;la cantidad de rastrojo incopporado no es muy alta(2882 y 745 Kg/Ha,respectivamente en ambos arados). La materia orgánica fluctúa en la vecindad de los valores iniciales,con picos en julio,debido presumiblemente a la escasa precipitación y bajas temperaturas de la época,que enlentecen la mineralización.En la siembra(5cm.) el arado múltiple en ambas labranzas anticipadas,acumula mayor cantidad de materia orgánica.

El nitrógeno total no presentó variaciones en los periodos analizados.

Los nitrificantes fueron estimulados por la incorporación de materia orgánica(efecto en la producción de amonio),sobre todo en la incorporación tardía de setiembre,en donde la mineralización es estimulada por condiciones climáticas favorables.Los fijadores de nitrógno del género Azotobacter presentan picos muy marcados en julio en los tratamientos con arado múltiple,relacionado a la acumulación de materia organíca que estimula a este grupo heterotrofo.

Se concluye que los distintos tipos de manejo que sufrieron los rastrojos no afectaron el nivel del nitrógeno mineral en el período crítico de la siembra,ni aumentaron significativamente el nitrógeno total y la materia orgánica. Esto se atribuye al hecho de que la enmienda orgánica no fue de una magnitud tal como para provocar alteraciones importantes en el equilibrio biológico del suelo.

La práctica de incorporar rastrojos del cultivo anterior contribuye a mantener el nivel de la materia orgánica,que en el caso de los monocultivos sin fertilizar,se torna muy importante.

Effects of Fallow Treatments in a Soil Cultivated with Corn on the Dynamic Evolution of the Organic Matter, the Nitrogen and Some Microbial Groups.

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The effects of three dates of incorporation of corn stubble: June,September and sowing day,carried out with combinations of 3 machines(one-way plow,duck-foot and chisel plow) were studied on nitrogen mineralization,organic matter evolution,total nitrogen and variation of the population densities of dinitrogen fixing bacteria of the genus Azotobacter and nitrifiers microorganisms. This study was carried out during two years in a field trial with corn,installed 4 years on a loam-sandy soil,at San Ambrosio,Dep. of Río Cuarto,Argentina,in a randomized block design with 9 treatments and three replications.

During this experiment weren't important problems of nitrogen inmobilization,probably because the quantity of incorporated stubble wasn't enoughly high(2882 and 745 kg/ha with one-way plow and duck foot respectivily) as to cause a great desequilibrium in the cycle of mineralization-inmobilization of soil nitrogen. At sowing, in the first horizon(0-20cm) the nitrates content varied around the control plot,but there weren't differences among the dates of tillage. The organic matter varied in the vecinity of the initial levels,with maximun values in July due probably to poor rains and low temperature that slow down the mineralization.

The total nitrogen didn't change in the analyzed periods.The nitrifiers groups were stimulated by the corn stubble,and the nitrogen fixing Azotobacter increase in July in the treatments with one-way plow,related with the organic matter accumulation.

We conclude that the practice of incorporation of corn stubble didn't affect the mineral nitrogen level in the critic period of sowing,didn't alter significantly the total nitrogen nor the organic matter levels.This was due to the fact that the stubble volumen wasn't of such magnitude as to produce important alterations in the biological equilibrium of this soil. This practice contribute to mantain the organic matter level,that is very important in our country, where the monocultivation of cereals without fertilization is common.

NITROGEN CYCLING IN COCOA AGROECOSYSTEM UNDER SHADE TREES: DISTRIBUTION IN THE DIFFERENT COMPARTMENTS AND LITTER FALL.

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The objetive of this work is to establish the distribution and fluxes of nitrogen in the cocoa plantation under shade. A 10 year old plot which had received no fertilization was selected in "Hacienda Monasterio" at 12 ma sl. Rainfall averages 739,79 mm/yr mean temperature and is 25,8ºC.

Total soil nitrogen (34,255 kg/ha) represents 51,3% of the total store for this nutrient. Nitrogen return to the soil by litter is 309.8 kg/ha of which shade tree leaves contribute with 53.4%. Shade trees are predominantly legumes which exploit deeper horizons than cocoa trees.

Most of the nitrogen in cocoa biomass in found in branches (89.9 kg/ha); roots contribute with 88.2 kg/ha of the total of 303.9 kg/ha.

The three main compartments in the agroecosystem: soil, crop biomass and litter contain 98.58%, 1,27% and 0.15% respectively.

Litter decomposition constant (K) for nitrogen is 8.4 with a half-life of some 30 days . Nitrogen is concentrated in the remaining litter while decomposition progresses, possibly due to microbiological activity as reported by Berg and Staaf (1979) for forest litter.

The nutrients (N,P,K, Ca and Mg) exported from the system by harvest make a total of 102,39 kg/ha of which nitrogen accounts for 44,65 kg/ha. The pod-shells which are returned to the field account for twice the account of N extracted by harvest (89 kg/ha of N). The return of N by litter fall (shade and cocoa) is 4 times greater than export by harvest.

The maintenance of fertility in cocoa plantation under shade and without chemical fertilizers, can be explained by high return of nitrogen as well as other nutrients by litter to the soil surface. The contribution of shade tree leaves is particularly relevant because the shade trees exploit deeper soil horizons as well as being active N fixers.

Biological N-fixations, nitrification and dentrification are presently being assessed.

CICLO DEL NITROGENO EN UN AGROECOSISTEMA DE CACAO CULTIVADO BAJO SOMBRA

El objetivo del trabajo es determinar la distribución y el flujo del nitrógeno en los diferentes compartimientos de un agroecosistema de cacao.

La estación experimental de cacao donde se desarrollo la investigación está ubicada en Ocumare de la Costa,Venezuela,a 12 msnm,con un promedio de presipitación anual de 739,79 mm y una temperatura de 20º C. Se escogió una parcela sin fertilización por 10 años y bajo sombra.

Los resultados demostraron que el nitrógeno total del suelo (34.255 Kg/ha) representa el 51,3% de su contenido total de nutrientes. El nitrógeno aportado anualmente por la hojarasca es de 309,8 Kg/ha . Las hojas de los árboles de sombra representan un aporte sustancial de nitrógeno de 53,4% del total,ya que estos explotan niveles más profundos del perfil del suelo y la mayoria de ellos pertenecen a la familia leguminosae. En la biomasa de los árboles de cultivo el mayor contenido de nitrógeno se encuentra en las ramas 89,9 Kg/ha y en las raices ''',2 Kg/ha del total de 303,9 Kg/ha.

Si se comparan los tres compartimientos estudiados: biomasa,hojarasca y suelo tomando en consideración el contenido de nitrógeno en este agroecosistema se observa que el mayor contenido de nitrógeno lo presenta el suelo (0-30 cm) 98,58%,la biomasa del cultivo 1,27% y la hojarasca del suelo 0,15%.

La constante de descomposición anual de la hojarasca para el nitrógeno es de 8,4 y un tiempo de vida media de aproximadamente un mes;encontrandose que a medida que avanza la descomposición de la hojarasca aumenta la concentración del nitrógeno en el remanente. Este aumento de concentración de nitrógeno posiblemente se deba a un proceso microbiológico semejante al reportado por Berg y Staaf (1979).

Parte de los nutrientes que son absorvidos por las raices del cultivo, son exportado del agroecosistema con la cosecha de los frutos. El análisis de

éstos nos revela que se exporta un total de 102,39 Kg/ha de nutrientes, correspondiendo al nitrógeno 44,65 Kg/ha de este total de una cosecha de 636 Kg/ha. El retorno de la cáscara del cultivo al agroecosistema es el doble de lo que se extrae por cosecha de la almendra (89 Kg/ha de N). Al comparar el aporte de la hojarasca de los árboles de sombra, se observa que éste es cuatro veces mayor de lo que se extrae de nitrogeno por cosecha de la almendra.

El mantenimiento de la fertilidad y productividad del cultivo bajo sombra y sin fertilización química puede ser explicado por el alto retorno del nitrógeno en la hojarasca de los árboles de sombra. La rápida mineralización del nitrógeno en la hojarasca haría disponible a las raices del cultivo un aporte sustancial frente a las salidas de nitrógeno por cáscara del fruto.

Los procesos de nitrificación, fijación de nitrógeno y desnitrificación se consideran importantes y los resultados están siendo procesados en la actualidad.

Observacoes Sobre a Dinamica do Nitrogenio em uma Plantacoa de Cacau

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Em uma plantação de cacaueiros comuns de 30-40 anos de idade instalada sobre solo Cepec *(Tropudalf)* na região Sul da Bahia, mediu-se a lixiviação e mineralização de nitrogênio pelo espaço de um ano. Lisímetros foram instalados a 0,10 m; 0,20 m e 40 m de profundidade, sendo coletado o lixiviado semanalmente ou após chuvas fortes. A mineralização foi medida em amostras coletadas a 0-5 e 5-15 cm de profundidade, incubadas por 30 dias em sacos plásticos no próprio campo à mesma profundidade e os resultados comparados com os das amostras coletadas no início da incubação. A lixiviação correlacionou satisfatoriamente com a chuva e os teôres de $N\text{-}NO_3$ e $N\text{-}NH_4$ foram inferior na área adubada com NPK que na ausência desse tratamento. Embora sendo bastante difícil quantificar a lixiviação por umidade de área, estima-se que as perdas de nitrogênio na área ensaiada sejam bastante pequenas. Alto grau, tanto de mineralização como de nitrificação ocorre durante a maior parte do ano, sendo este último processo bastante rápido e de maior magnitude nas amostras da área adubada. Nestas amostras, entretanto, menores quantidades de $N\text{-}NH_4$ foram encontradas, possivelmente, como resultado de uma maior nitrificação. Entre 5 a 8 toneladas de matéria seca na forma de folhas de cacau caem anualmente, contribuindo assim com 60-90 kg de nitrogênio; concorrendo a eritrina através de flores, ramos, folhas e sementes com aproximadamente 2 toneladas de matéria seca contendo 30-60 kg ha^{-1} desse nutriente. Nenhuma diferença consistente foi encontrada no conteúdo de nitrogênio total de amostras de solos coletados longe e perto de árvores de sombra; ocorrendo porém 440 $\mu g\ g^{-1}$ a mais de nitrogênio nas amostras coletadas sob sombra que nas amostras da parte

da plantação sem sombra. Discutem-se os ganhos de nitrogênio em relação com os requerimentos do cacaueiro até chegar a fase adulta, bem como, as quantidades desse elemento exportadas através da produção de sementes. Ressalta-se, finalmente, a importância desse balanço na elaboração de tabelas de adubação.

In the cacao region of Southern Bahia, Brazil, both nitrogen leaching and mineralization of organic nitrogen were studied in NPK fertilized and unfertilized plots in a 30-40 yr-old cacao plantation on "CEPEC" soil (Tropudalf) during a one year period. For the former, small lysimeters were located at depths of 0.10, 0.20 and 0.40 and leachates were collected weekly or after heavy rains. Mineralization was assessed from soil samples taken at depths of 0-5 cm and 5-15 cm and stored in plastic bags for 30 days under field conditions. The results from these samples were compared with those at zero storage time. On the average, there was a good correlation between leaching and rainfall. Both $N\text{-}NO_3$ and $N\text{-}NH_4$ were lower in the fertilized area than in the control. Although extrapolation of the lysimeter results to hectare values is difficult to do, the amount of nitrogen in the leachates was small. High degress of both mineralization and nitrification were recorded during most of the year. Apparently the latter process took place very rapidly and was higher in the samples from the fertilized area. However, unexpectedly smaller of $N\text{-}NH_4$ were recorded in these samples, probably resulting from higher nitrification. Cacao leaf fall, estimated at 5 to 8 ton/ha/year represented 60 to 90 kg ha^{-1} of nitrogen and in addition, organs shed by shade trees of Erythrin sp. amounted to almost 2 tons/ha^{-1}, being responsible for a further 30-60 kg/ha^{-1} of that nutrient. No differences were recorded in relation to distance from shade trees in terms of total soil nitrogen. However, the average nitrogen content of soil samples form shade cacao was 440 $\mu g\ g^{-1}$ higher than those from unshaded area. The contribution inputs resulting from these processes are discussed with regard to nitrogen requirements for development of cultivation and replacement of losses through removal of material harvested. It is recommended that attention be given to all these factors in the elaboration of fertilizer recommendation tables.

THE IMPORTANCE OF NITROGEN FIXATION BY NON-CROP LEGUMES IN COFFEE PLANTATIONS

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Fertilizer studies in Mexico indicate a positive correlation between coffee production and nitrogen availability. One method of coffee cultivation traditionally employs leguminous trees for shade, but these species may also play an important role in coffee production through nitrogen inputs via fixation.

This study establishes the presence and quantity of nitrogen fixation associated with various ecosystem components in four coffee sites. Site 1 contained coffee. Sites 2 and 3, coffee and leguminous shade trees, Inga jinicuil Schletchter or Inga vera H.B. and K., respectively. Site 4 had coffee, banana, and orange trees. Soil, coffee leaves with epiphylls, roots, and root nodules were assayed for nitrogen fixing activity using the acetylene reduction technique. All materials exhibited activity except root nodules. Overall,fixation was highest in site 2, over 40 kg/ha/yr, due largely to fixation activity associated with root nodules of I. jinicuil. Fixation in the other sites equaled less than 1 kg/ha/yr. Nitrogen additions from fixation in site 2 approximate fertilizer nitrogen additions in some plantations. This study suggests that non-crop legumes are an important source of nitrogen for the coffee agro-ecosystem.

NITROGEN CYCLING IN COFFEE AGROECOSYSTEM UNDER SHADE TREES: DISTRIBUTION IN THE DIFFERENT COMPARTMENTS AND LITTER FALL

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The objetive of this work is to establish the distribution and fluxes of nitrogen in a coffee plantation under shade. A 20 year old plot which had received no fertilization was selected in "Hacienda La Cumaca" at 1380 ma sl. Rainfall averages 1200 mm/yr and mean temperature is 20ºC.

Total soil nitrogen (49057 kg/m) represents 81.6% of the total store for this nutrient. Nitrogen return to the soil by litter is 169.6 which shade-tree leaves contribute with 46.2%. Shade trees are predominantly legumes which exploit deeper soil horizons coffee trees. Most of the nitrogen in coffee biomass in found in branches (119.7 kg/m); leaves contribute with 61.7 kg/ha of the total 254 kg/ha.

The three main compartment in the agroecosystem: soil,crop biomass and litter contain 98.6% , 1.38% and 0.02% respectively.

Litter decomposition constant (k) for nitrogen in 4.13 with a half-life of some 45 days. Nitrogen is concentrated in the remaining litter while decomposition progresses, possibly due to microbiological activity as reported by Berg and Staaf (1979) for forest litter.

The nutrients (N, P, K, Ca and Mg) exported from the system by harvest make a total of 57.12 kg/ha of which nitrogen accounts for 17.22 kg/ha. After separating pulp and beans 3,19 kg/ha are traditionally returned to the field with the former. The return of N by litter fall (shade and coffee) is 25 times larger than export by harvest.

The maintenance of fertility in coffee plantations under shade and without chemical fertilizer, can be explained by the high return of nitrogen as well as other nutrients by litter to the soil surface. The contribution of shade-tree leaves is particularly relevant because the shade trees exploit deeper soil horizons as well as being active N-fixers.

Biological N-fixations, nitrification and dentrification are presently being assessed.

CICLO DEL NITROGENO EN UN AGROECOSISTEMA DE CAFE CULTIVADO BAJO SOMBRA

El objetivo del trabajo es determinar la distribución y el flujo del nitrógeno en un agroecosistema de café.

Para llevar a cabo la investigación se escogió una parcela sin fertilización por 20 años y bajo sombra,la cual esta ubicada en la Hacienda La Cumaca,estado Miranda,Venezuela,a una altura de 1380 msnm con un promedio de precipitación anual entre 1119 y 1307 mm y una temperatura de 20º C.

Los resultados desmostraron que el nitrógeno total del suelo (49,057 Kg/ha) representa el 81,6% de su contenido total de nutrientes. El nitrógeno aportado anualmente por la hojarasca es de 169,66 Kg/ha. Las hojas de los árboles de sombra representan un aporte de nitrógeno de 46,2% del total,ya que éstos al igual que en el caso del cacao explotan niveles más profundos del perfil del suelo y la mayoría de ellos pertenecen a la familia leguminosae. En la biomasa de los árboles de cultivo el mayor contenido de nitrógeno se encuentra en las ramas 119,7 Kg/ha y en les hojas 61,68 Kg/ha del total de 254 Kg/ha.

Considerando el contenido del nitrógeno en los tres compartimientos estudiados del agroecosistema:biomasa,hojarasca y suelo (0-30 cm) 98,6%,la biomasa del cultivo 1,38% y la hojarasca del suelo 0.02%.

La constante de descomposición de hojerasca para nitrógeno anual es de 4,13 y un tiempo de vida media de aproximadamente mes y medio,encontrandose que a medida que se va descomponiendo la hojarasca aumenta la concentración del nitrógeno en el remanente. Este aumento de concentración de nitrógeno posiblemente se deba a un proceso microbiológico semejante al reportado por Berg y Staaf (1979).

Parte de los nutrientes del agroecosistema son exportado con la cosecha de los frutos. Se exporta un total de 57,12 Kg/ha de nutrientes correspondiendo al nitrógeno 17,22 Kg/ha de este total,de una cosecha de 700 Kg/ha de fruto completo. Retornando al agroecosistema 3,19 Kg/ha de nitrógeno por concepto de pulpa de café. Al comparar el aporte de la hojarasca de los árboles

de sombra se observa que es 25 veces mayor de lo que se extrae por cosecha.

Al igual que en el caso del cultivo de cacao el mantenimiento de la fertilidad y productividad de cultivos bajo sombra y sin fertilización química puede ser explicado por el alto retorno del nitrógeno en la hojarasca de los árboles de sombra. La rápida mineralización del nitrógeno en la hojarasca haría disponible a las raices del cultivo un aporte sustancial frente a las salidas de nitrógeno por cosecha del fruto .

Los procesos de nitrificación,fijación del nitrógeno y desnitrificación se condideran importantes y los resultados estan siendo procesado actualmente.

The effect of mycorrhizal fungi on the nitrogen cycle of rice and banana plantations under sub-tropical conditions.

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Rice plants (Oryza Sativa L.) and Banana plants (Musa paradisica L.) were grown under controlled pH conditions in which the most important factor by which the nitrogen complexes were derived from the digestion of proteins created by countless millions of bacteria whose dead bodies left specks of protein in the soil - after being intensively multiplied - by a certain type of fertilizer created through investigations conducted by the Academy of Sciences of the Dominican Republic.

This fertilizer named " Biorgan " is a combination of such tropical superior strains of aerobic bacteria and algae which are mixed in a series of host mediums, in themselves consisting of selected caustobiolites of potentially high fertilizing hexagonal carbon biocrystals, combined with auxons, auxins, hormones and certain antibiotics, to sustain them while they adapt to the soil environment in which they are placed. Among it's unique properties is the capability to generate constantly and in a sustained manner organic nitrogen and oxigen around the roots of the plant.

The results of these trials may be summarized as follows: at all stages of the plant development the uptake of nitrogen by the rice or banana plants was greater although a little slower than in the test plots.

However due to the constant and virulent microbial activity sustained by this new organic-mineral biofertilizer, the nitrogen contents were higher in the soil at the end of the growing cycle than at the beginning, this unusual condition being credited to the activity of the mycorrhizal fungi present around the roots.

This new method had an additional benefit for tropical soils in general; all nematodes in the soil - around the plant roots - were dead after the first week of the application of Biorgan a completely non-toxic

THE RHIZOBIUM-LEGUME SYMBIOSIS IN LATIN AMERICA

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Throughout Latin America the leguminous plants constitute important items in the economy of the countries and/or for the production of food for the people. In many areas of low income people legumes are the main source of protein food.

A relatively high number of institutions and researchers are with variable intensity working on Rhizobium. Main centers of Rhizobium research are located in Brazil, Argentina, Uruguay, Colombia and Mexico.

However in only two countries (Brazil and Uruguay) the wide spread use of inoculants has given an important contribution for the dissemination and productivity of grain and forrage legumes. Several factors are responsable for this situation: inadequate training of researchers and agronomists, low effort by the extension services, inexistence of legume promotion programs, low level of education of the farmers, etc.

The Microbiological Resources Center (MIRCEN) in Rhizobium (Agreement UNEP/UNESCO/ICRO-IPAGRO/UFRGS) established in Porto Alegre, Brazil, is contributing to improve the use of the legumes and gathering of higher benefits from the symbiotic nitrogen fixation. Before the establishment of the MIRCEN Program several scientists were trained at IPAGRO/UFRGS Laboratories at intern practical training and graduate regular courses at M.S. level. In total MIRCEN (1979-1980) has already trained 45 scientists in Rhizobium Technology at two short courses and intern practical trainirg. Besides training MIRCEN activities comprise inoculant production and

quality control, dissemination of rhizobia strains, dissemination of information and a research program mainly with beans (*Phaseolus vulgaris*), soybeans, alfalfa, clovers and other grain and forage legumes of minor importance.

The potential of the better use of legumes and the symbiotic N2 fixation is high in the region. Improvement should be based on (a)training of rhizobiologists, legume researchers, extensionists and administrators at international and national short courses, seminars, etc. (b) training of high legel rhizobiologists at M.S. and Ph.D. level through fellowships offered to some key laboratories at each country (c) promotion of workshops at national level calling together rhizobiologists, legume researchers and extension leaders (d) improvement of the research capability (e) promotion for the production of high quality laboratory made inoculant to function as a standard and promote the difusion of the inoculation pratice (f) promotion for the establishment of inoculant quality regulations and a quality control laboratory at each country.

THE LEGUMES AS A SOURCE OF NITROGEN IN PERU

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The physical factors of the Cordillera de los Andes and the Pacific Ocean change the climatical factors which typified the Tropical Zones where is Perú belonged. In this form there are different ecosystems each one is a peculiar one. And within the sistems, in the Nitrógen cycle the biological factor of symbiosis between the legumes species and the Rhizobium bacteria with the formation of radicular nodules permit the byological fixation of the nitrogen atmosferic. Next of a series of metabolic reations it is form vital compounds for cells as proteins and others.

The legumes species are the more privileged because they, constituted a nitrogen source for the ecosystems where they are included. If they are no present, appear a limitant factor for t the byological production and the stability of the ecosystem.

For Perú three phytogeographic territories are cited, within these are important the following legumes:

1.For the Costaner territory, in the Lomas destacate species of the genera Weberbauerella, Vicia, Caesalpinia. In the Ecosystem Algarrobal + Sapotal the species of the genera Prosopis, Stylosanthes. In the Ribera Monte are mentioned Acacia macracantha, Vigna luteola. Besides, the cultivated species Phaseolus vulgaris, Ph. lunatus, Glycine max and Medicago sativa.

2. For the Andino Territory according to the altitudinal level are present species of the genera Lathyrus, Vicia, Lupinus. Within the cultivated species are important Lupinus mutabilis, Phaseolus vulgaris, Vicia faba, Pisum sativum, Medicago sativa and Trifolium repens..

3. For the Llanura Amazonic Territory are important the species of the genera Mucuma, Inga, Myroxylon, Cassia, Tephrosia, Centrosema.and others. Within the cultivated species are cited Arachis hypogaea, Stylosanthes guianensis, Centrosema pubescens and Pueraria phaseoloides. The latter is easily stablished in the devastated land and is considered promisor as a nitrogen source for the tropic.

Varición estacional de actividad de nitrogenasa y nitrato reductasa en *Lens esculenta*, *Vicia atropurpurea*, *Lupinus luteus*, and *Pisum arvense* L. Longeri

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Potential growth of Alfalfa in the desert of Southern Peru and the response to a high NPK fertilization

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Irrigated highly fertilized Alfalfa in the deserts of Southern Peru, reached potential growth rates of about 200 Kg. Ha^{-1} day^{-1} dry forage during Summer period and of 150 Kg. Ha^{-1} day^{-1} during Winter. This high rate could be maintained only for 10 to 20 days, after which a leveling off was taking place up till a ceiling yield of about 5000 Kg. dry forage in Summer and of 3500 Kg. in Winter, during a growth period of 52 days. First simulations with an adapted DACROS model, indicates that a declined photosynthesis rate of aging leaves is a probable cause for this phenomenon. Simulated growth curves were also very much influenced by the level of reserves in the root system at harvest.

High NPK fertilization increased available mineral N in soil two fold, available K 1.6 fold and available P 4.3 fold, but this contributed only to about 10% increase of maximum growth rate as well as ceiling yields. Analysing plant contents, there was only a significant response to P-fertilization and a very slight, non-significant, response to K fertilization.

High N fertilization did not increase the N-content of the plant, indicating that the present Rhizobia are able to fix up till 1000 - 1200 Kg. N. Ha^{-1} $yr.^{-1}$. Commercial inoculants virtually did not improve this N fixing potential as even in virgin desert soils (no vegetation before) after a few (harvests) yields as well as N contents of non inoculated alfalfa were of the same magnitude as inoculated alfalfa, indicating an effective natural inoculation, probably through irrigation water.

Nitrogen Cycling in Flooded Soils Planted to Rice

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Agronomically, flooded soils are used for growing lowland rice (Oryza sativa L.), the major food for approximately 50% of the world's population. Throughout the rice growing areas of the world, nitrogen is the most common nutrient limiting the growth and yield of rice. Nitrogen inputs (gains) to the flooded soil ecosystem comes from (1) application of fertilizers; (2) incorporation of crop residues; (3) biological N_2 fixation; (4) interflow, runoff, and irrigation water; (5) atmospheric NH_3, N_2O, and NO absorption by soil and plants; and (6) rainfall. Nitrogen outputs (losses) from the flooded soil ecosystem include (1) crop removal; (2) simultaneous occurance of nitrification-denitrification reactions; (3) NH_3 volatilization; (4) fixation of NH_4-N by clay minerals; (5) leaching and surface runoff. This paper examines the agronomic and ecologic significance of N processes controlling N utilization by rice, and their role in determining N loss or gain to the flooded soil ecosystem.

Nitrogen in flooded soils occurs in inorganic and organic forms with the organic form predominating. Organic N consists of compounds from amino acids, amines, proteins, and humic compounds with low N content. Inorganic N consists of ammonium N, nitrate N and nitrite N. Ammonium N is the predominant form of irorganic N derived from mineralization of organic N and application of fertilizers. The gaseous forms of N that occur in this agroecosystem include NH_3, N_2, and N_2O. A series of biochemical and physicochemical processes as described above are involved in transforming one source of N to another source.

Studies conducted by the author using ^{15}N techniques revealed that approximately one-third of fertilizer N applied to rice was recovered in the grain, approximately one-fifth to one-fourth was recovered in the straw, approximately one-fourth remained in the soil and roots, with remaining one-fifth to one-fourth of the added N lost from the system. Incorporation of crop residues resulted in less than 10% of the added N released during the second year. The loss mechanisms were identified in the studies conducted under laboratory conditions. From the results it was concluded that nitrification-denitrification, involved in the ammonium N loss from the soil, whereas NH_3 volatilization occurs under specialized conditions, mainly in the overlying water. The sequential process involved in N loss include ammonification of organic N to ammonium N in the soil, upward diffusion of ammonium N (0.06-0.85 cm^2/day) into the surface aerobic soil layer, nitrification of ammonium N (1.1-2.7 $\mu g/cm^3$/day) in the aerobic soil layer or volatilization of NH_3 under specialized conditions, downward diffusion of nitrate N (0.25-1.94 cm^2/day) into the anaerobic soil layer, and denitrification of nitrate N (0.03-0.9/day) to the gaseous end products such as N_2 and N_2O. Losses of N through these mechanisms accounted to about 20-50% of the added N. Additional studies showed that about 0.2-0.4 kg N/ha/day was gained by the flooded soil through biological N_2 fixation. A major portion of the N_2 fixation occurred at the floodwater-soil interface.

Fixation And Crop Utilisation Of Added Nitrogen In West Indian Soils

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A series of experiments on N fixation by inorganic and organic soil components and on crop utilisation of fertilizer nitrogen were carried out on a range of Caribbean soils of varying properties using ^{15}N labelled fertilizer materials.

Fixation by clays was rapid and considerable for the 2:1 lattice type minerals and the process was almost complete after one week; it was increased with rate of application of NH_4-N and at elevated temperatures in the soils were allowed to air dry. NH_4-N fixation was more active in the fulvic fractions of the soil organic matter, compared to the humic fractions.

Plant uptake of added NH_4-N in greenhouse experiments showed that a greater percentage of fertilizer - N was taken up by Sudan grass (*Sorghum sudanese*) as the application increased from 40 to 200 kg/ha N.

From field experiments with maize (*Zea mays*), it was found that fertilizer - N as urea was rapidly lost when applied to soils in a wet tropical environment. At normal rates of application (100 kg/ha) only about half of the fertilizer was utilised by the crop. Use of mulches did not significantly affect the fate of added nitrogen; however, it resulted in increased yields in dry season cropping due probably to water conservation effects.

There is good i dication that in conditions in Trinidad NH_4-N is better utilised and less subject to unidentified losses compared to urea. Addition of fertilizer N resulted in mineralisation and crop uptake of important quantities of native soil nitrogen.

NITROGEN - 15 IN SOIL FERTILIZATION STUDIES AND CROPS PRODUCTION

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The enhancement of fertilizer efficiency requieres a better knowledge of the crop's use of nitrogen fertilizer during the entire growing season. One tool to study the undisturbed system is nitrogen with an altered isotopic ratio. Naturally occuring nitrogen in all of its phases has a constant ratio of about 273 atoms of atomic weight 14 (N^{14}) to each atom of atomic weight 15 (N^{15}). Materials with an unusually high or low concentration of N^{14} or N^{15} can be used as tracers.

A review is presented on results obtained by scientists involving the use of N^{15} in nitrogen studies in soil-plant systems. Quantitative information for the major nitrogen cycle processes in different experimental systems (greenhouses, lysimeters, closed sysimeters, etc.) is available, specially for nitrogen recovery by crops and balance.

The high cost of N^{15} depleted compounds and the equipment needed for N^{15} analysis are discussed. This is a serious hindrance to use of this isotope as a tracer for soil-plant studies in Latin America.

RESPUESTA DEL MAIZ (Zea mayz) EN PRODUCCION DE GRANO RASTROJO, MATERIA SECA Y ABSORCION DE N, A DIFERENTES NIVELES, FUENTES Y OPORTUNIDADES - DE APLICACION DE N

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En un experimento de campo efectuado en Chapingo, se estudió la respuesta de un cultivo de maíz en términos de producción de grano, rastrojo, materia seca y absorción de N, a diferentes niveles de N (0, 40, 80, -- 180, 160 y 200 Kg/ha), tres fuentes nitrogenadas (sulfato de amonio nitrato de amonio y urea) y cinco momentos de aplicación (todo a la siembra, todo a los 30 días, todo a los 50 días, 1/2 a la siembra y 1/2 a - los 30 días, 1/2 a la siembra y 1/2 a los 50 días). La evaluación de - la materia seca y absorción de N por la planta se hizo en cinco épocas del desarrollo del cultivo: a los 30, 54, 100, 130 y 193 días de la siembra, correspondientes a los estados fenológicos de crecimiento inicial, crecimiento acelerado, jiloteo, llenado de grano y cosecha, respectivamente.

Las conclusiones a las que se llegaron fueron los siguientes: El rendimiento en grano y rastrojo respondió significativamente hasta el nivel de 120 kg N/ha, las dósis mas altas no ejercieron mayor influencia sobre el rendimiento, apreciándose sin embargo una tendencia detrimental no - significativa al nivel mas alto de fertilización (200 - kg/ha). La fuente nitrogenada que mejor comportamiento tuvo fué el sulfato de amonio, en segundo lugar quedó la urea sin distinguirse significativamente del sulfato de - amonio, y ambos superaron estadisticamente al nitrato de

amonio. En cuanto a producción de materia seca y absorción de N por la planta, en la mayoría de los cortes los mejores resultados se obtuvieron con la dósis de 100 kg N/ha; la dósis mas alta(200 kg N/ha) produjo efectos detrimentales significativos en ambos casos, tanto en formación de materia seca como en absorción de N. El sulfato de amonio fué el fertilizante nitrogenado que mejor resultado dió tanto en formación de materia seca como en absorción de N. En la mayoría de los cortes las aplicaciones a la siembra superaron a las aplicaciones tardías, en producción de materia seca y absorción de N por las plantas.

S U M M A R Y

In one field experiment carried out in Chaingo, the response of a corn crop was studied in terms of grain and stubble production, dry matter and N absorption, under five doses of N fertilization (0, 4o, 8o, 120, 160 and 200 kg/ha), three sources of N (ammonium sulfate, ammonium nitrate and urea) and five dates of application (all at sowing, all 30 days after sowing, all 50 days after sowing, 1/2 at sowing and 1/2 30 days later, 1/2 at sowing and 1/2 50 days later). The evaluation of dry matter and N absorption was made in five dates during the crop development: 30, 54, 100, 138 and 193 days after the sowing, which corresponded to initial growth, rapid growth, silking, filling and harvest, respectively.

It was concluded: The grain and stubble yields, responded significantly to nitrogen up to 120 kg/ha; the higher doses did not produce higher increase on the yield; it was nevertheless to appreciate, although not significantly, a detrimental tendency at the highest doses (200 kg N/ha). The N source with the best behavior was ammonium sulfate, in second place was urea and after this, ammonium nitrate. The fertilization at sowing date (all in one application or divided in two) was better than the later applications. In general, in respect to dry matter and N absorption, the better results wew also found with the doses of 120 kg N/ha; the highest doses produced detrimental effects, significant in both grain yields and N absorption. The ammonium sulfate was the N source that gave the best result, in dry matter production and N abdorption. In most of the cuts the fertilization at sowing time was better than later fertilizations both in production of dray matter and in N absorption.

EFFECT OF PLOUGHING UNDER CROP RESIDUES ON SOIL NITROGEN UNDER WHEAT AND MAIZE

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The effect of ploughing under crop residues in two levels had been studied on soil nitrogen, nitrogen balance and asymbiotic nitrogen fixers (Azotobacter and clostridia at Giza, Egypt. The crop rotation included wheat and maize. Results revealed that crop residue addition induced relatively little widening of the C/N ratio, mineral and total nitrogen level were generally higher in treated plots than control. In no case did the plants on the treated soils show signs of nitrogen deficiency. Nitrogen balance showed that deficits were the general rule in soils receiving no additional plant residues. Incorporation of plant refuse diminished or covered the deficits or even resulted in gains. Plant residues, wide in C/N ratio, maintained dense population of Azotobacter, clostridia; increased soil nitrogen by encouraging biological nitrogen fixation and by supressing nitrate formation which may be lost through leaching or denitrification.

Concepto de Ecosistemas en Cuencas Hidrograficas y Estudios de Ciclos de Nutrientes

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THE FATE OF UREA APPLIED TO TROPICAL BEAN (*Phaseolus vulgaris*, L.) CROPS

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Due to the important role of nitrogen as a plant nutrient, it is essential to fully understand how it is recycled in agriculture. Many studies have already been conducted along these lines, but very little information is available for tropical conditions where the mobility and mineralization rate of nitrogen are very high. The increasing cost of nitrogen fertilizers also demands that management practices should result in a high utilization efficiency of N by crops. Since many crops respond greatly to N fertilization, the tendency to overfertilize has resulted in some situations, in ground water contamination through leaching of NO_3^- below the root zone.

Having these concerns in mind, the present study had the objvective of understanding the fate of applied nitrogen to bean crops grown on a soil in the tropics. Urea labeled with ^{15}N was used in order to estimate crop recovery of N (and its utilization efficiency) residual effects of N from one crop to another, distribution of N in the soil profile after cropping and leaching losses of N.

Results show that the first crop recovered on the average 31.2% of the N from the applied urea which represents a utilization efficiency of 38.5%.

The second crop recovered 6.2% N from the fertilizer applied to the first crop. The third crop recovered only 1.4%. The nitrogen utilization efficiency for these two crops, with respect to the N applied to the first crop, were 4.5 and 1.1%, respectively. So, the three crops recovered 44.1% of the N applied to the first crop. The remainder of the N was either still in the soil profile or had been lost by leaching, volatilization or denitrification. The ^{15}N enrichment data of the mineral N (NO_3 + NH_4) show that at the end of the second crop the pulse of fertilizer applied to the first crop, had probably passed the 120 cm depth. Comparing mineral N in the soil of fertilized plots with the check plots we see that for all three crops fertilized plots had greater amounts of N. In the case of organic N, no signifficant difference can be seen between fertilized and

check plots. The ^{15}N enrichment data for organic N, show that root activity (of beans and weeds) must have transported N down to the layer 90-120 cm (or deeper).

The mass balance of N at the end of the first crop gives 110.9 kg N/ha showing an error of about 11%, assuming no N was lost by volatilization or denitrification. At the end of the second and third crops the balances give 75.7 and 79.3 kg N/ha, respectively, showing that 20 to 25% of the applied N should have been lost from the system. However, as discussed above, all values have a great error, which is difficult to estimate. This shows again the difficulties envolved in making N mass balances under field conditions.

UREA TRANSPORT AND TRANSFORMATION IN TWO DEFORESTED AMAZONIAN SOILS

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Brazilian agriculture is now expanding toward the Amazon region, where large new areas of virgin lands are being brought under cultivation. There is therefore an urge to get knowledge of the conditions and characteristics of the soils of that region.

In this paper, two soils, one Red Yellow Podzol and Yellow Latosol were used to study urea transport and transformation in the laboratory, under water saturated conditions. Soil samples were collected in an area that was deforested in 1976 and planted to tropical fruits since then.

Miscible displacement techniques were utilized, under both continuous feed and pulse application of urea, and its transport and transformation was mathematically described as function of depth and time. Transformation mechanism was considered to be first order kinetics.

Urea was found to be readly leached from both soils. Recovery of urea in the efluent of the columns was 91% for the Podzol and 86% for the Latosol. NH_4^+-N originating in urea hydrolisis was also readly leached and its recovery in the efluent was 4,2% for the Podzol and 11,2% for the Latosol. Very little nitrogen was left in the column, either as exchangeable NH_4^+-N or biomass nitrogen at the end of the experiment, for both soils.

Data points out that extremely careful management of these soils and fertilizer nitrogen should be exercised in order to prevent nitrogen losses.

IMPACTO DEL RIEGO CON AGUAS SERVIDAS NO TRATADAS SOBRE EL BALANCE DE N.

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The impact of nitrogen forms present in non-treated domestic and industrial sewage waters on land and crops irrigated with them were studied.

Nitrogen input from this source was approximately 700 Kg/ha/year. Wells located in the area studied receive the drainage water of the sewage irrigated croplands and their nitrate pollution exceeded in some instances the accepted maximum levels for human consumption.

Nitrate-N content and excess nitrogen in the unsaturated soil below the root-zone were determined and found to be appr. 250 Kg/ha/year.

Transit time to reach the saturated zone was found to be less than one year. Total-N in crops grown in this fields was also determined.

An attempted nitrogen balance accounted for 60-70% of the N-input. The difference or N-loss could be due to denitrification processes or immobilization in organic forms.

EUTROFIA EN LA LAGUNA DE ACULEO .

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Los estudios de productividad primaria son fundamentales para entender el flujo de la energía en los primeros niveles de un ecosistema y al mismo tiempo el estado de eutrofía de un lago o laguna. Entendiendo por eutrofía de acuerdo a Margalef (1976) la capacidad de producción de un sistema.

Al encontrar un cuerpo de agua, cuya curva de oxígeno presenta fuertes depleciones llegando a cero en el fondo, al detectar esporádicas mortandad masivas de peces y cuando el color verde del agua la hace poco agradable para la natación y en general para los deportes acuáticos, con seguridad nos encontramos frente a un lago eutroficado. Este es el caso de la Laguna de Aculeo en Chile.

El objetivo de esta comunicación es intentar aproximarse a un valor del flujo de nitrógeno que éste cuerpo de agua cicla durante un año, a través de los valores de fijación de carbono de las algas fitoplanctónicas.

Se espera que los antecedentes adquiridos, sirvan de apoyo para que los niveles de decisión y de manejo puedan tomar las medidas requeridas para mantener, mejorar o enriquecer este ambiente.

Eutrophication processes in Aculeo lagoon

Sergio Cabrera S. y Vivian Montecino B.

Aculeo (33°50' 30" S. y 70°54' 24" W.) is a shallow lagoon ($\bar{Z}$ = 4,4 m) with scarcity of oxygen in the bottom layers. The colour of the waters is green due to high algal biomass. In this lake the fish assemblage undergoes periodic starvation.

By meam of primary productivity measurements we shall attempt to know the nitrogen fixation in the algal comunity during a year.

Morphometric features were obtained with an Echosounder, photosintetic active radiation (P.A.R.) with an air and a sub-aquatic quantum sensor. Other parameters like T°, pH, O_2, clorophyll were measured following standart procedures. In the central part of the lake (7 m depth) primary productivity was measured "in situ" periodically with 14 carbon method at depths where P.A.R. was equivalent from 100% to 3% of incident radiation at the surface.

Clorophyll "a" fluctuates between 28 mg m^{-3} to 487 mg m^{-3} primary production between 3.8 $\pm$ 0.9 and 578 $\pm$ 25 mg C m^{-3} h^{-1} . This results were then calculated for each strata with the hypsographic curve assuming horizontal homogeneity, annual values were calculated with total incoming radiation data.

A correlation (r) = 0.9339 ($p < 0.05$) between carbon fixation and clorophyll "a" was found in the photic zone.

In order to check the assumption of horizontal homogeneity 8 stations were sampled with an integrationg bottle between 0 and 3 m to determine total clorophyll "a" content. The values obtained ranged between 88.7 - 120.8 mg m^{-3}. The analysis of horizonted homogeneity showed that our estimates based on a single station could have been biassed from 5.7% to 26%.

Total C fixed in one year is estimated to be 5180 ton. Using from the literature an average C:N ratio of 6, nitrogen fixation in Aculeo can be estimated to be 850 ton. yr^{-1}.

Effect of Fertilizer on the Ecology of Feeding on *Brassica* crops

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Seasonal and daily variations in N fixation rates by epiphylls in a tropical rainforest.

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Although rainforests are not generally known for environmental variation, fixation rates by free-living bluegreen algae growing on the surfaces of understory plants can be quite variable. Rates range from 0 to more than 150 $ngN/cm^2/day$ and depend on such factors as light intensity at the leaf surface, time of last rainfall, and abundance of co-occuring bryophytes. The total contribution of new N by epiphyllous fixers to the ecosystem may be low, but the contribution to an individual host plant could account for 15-20% of the nitrogen needed for new growth.

POSSIBILITIES OF DOMESTICATION OF SOIL BACTERIA TO AVOID SOIL EROSION AND TO FIX BIG AMOUNTS OF NITROGEN FROM THE AIR USING CELLULOSE AS RENEWABLE ENERGY SOURCE

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According to our investigations and those of the Soriano et al. at.our laboratory the old enigma of energy sources for the nitrogen fixation by Azotobacter could be considered solved.

By means of new methods for cultivating Azotobacter in soil plaques without sterility, the ecological approach to cultivate nitrogen-fixing bacteria could be made at any laboratory of soils, without special microbiological equipment.

The practical possibilities open by the utilization of cellulose (stubbles) as producers of polyuronic colloids in aerobiosis that made soils resistent to erosion and at the same time the same cellulose in semi-anaerobic or anaerobic conditions, conditions that prevails in soils during wet period produces as byproducts ethyl alcohol and volatile organic acids that are very good energy sources for the Azotobacter that grows in the inter-fase air-water.

These ecological sequences to fix nitrogen from the air using a very cheap renewable source of energy could be an important new way to solve the nitrogen problem all over the world, specially in the Third World.

NUTRIENT DISTRIBUTION IN ECOSYSTEMS OF THE CENTRAL-WEST OF ARGENTINA

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Studies were carried out in two different cases, in which the main purpose of research was estimating primary productivity, together with nitrogen, carbon and energy content in plant fractions, litter and soil:

I. A secondary succession community -eight years old- of the western (dry) Chaco forest, with Aspidosperma quebracho blanco and Prosopis nigra as dominants. The area is located in a plain surrounded by pampean sierras of La Rioja (coordinates: 30° 30' S and 66° 15' W; altitude: 467 m). The climate is desertic, warm tropical, monzoonic and the soil is of alluvial granitic origin.

II. A xerophytic open forest of Prosopis flexuosa, intensively modified by felling 50 year ago. It is located in the pampasic plain of Mendoza (coordinates: 34° S and 68° W; altitude: 572 m). The climate is desertic, monzoonic, the soil is sandy loam, of eolic origin.

The present use of the plant communities -representative of extended areas of the argentinean West- is essentially for grazing and browsing. However, land is frequently being reclaimed for agriculture: in the chacoan forest, extensive dry-farming cultures; in the Mendoza "Monte", intensive cultures irrigated with river and groundwater.

DISTRIBUCION DE NUTRIENTES EN ECOSISTEMAS DEL CENTRO OESTE ARGENTINO

Se presentan dos casos estudiados, en los cuales el propósito principal de los trabajos ha sido el de estimar la productividad primaria, junto con los contenidos de nitrógeno, carbono y energía en fracciones vegetales, mantillo y suelo:

I. Un renoval de ocho años, del bosque chaqueño occidental (seco), cuyos dominantes son Aspidosperma quebracho blanco y Prosopis nigra. El área se encuentra en un ámbito de llanura enmarcado por las sierras pampeanas de La Rioja (coordenadas: 30° 30' S y 66° 15' W; altitud: 467 m). El clima es desértico tórrido, subtropical, monzónico; el suelo es aluvial, derivado de granitos.

II. Un bosque xerofítico de Prosopis flexuosa, muy abierto, intensamente modificado por la tala hace 50 años. El mismo se encuentra el la llanura pampásica de Mendoza (coordenadas: 34° S y 68° W; altitud: 572 m). El clima es desértico, monzónico; el suelo es franco arenoso, de origen eólico.

El uso actual de las comunidades vegetales presentes -representativas de áreas muy extensas del oeste argentino- es esencialmente pastoril. Pero, con frecuencia, se habilitan tierras para el uso agrícola: en el bosque chaqueño, cultivos extensivos de temporal; en el "Monte" mendocino, cultivos intensivos, con riego derivado de ríos y agua subterránea.

PRIORITY RESEARCH AREAS IN NITROGEN STUDIES

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In all ecosystems the 'Nitrogen Cycle' is controlled by the rates of input and output of nitrogen and internal cycling processes. The rates of these three parameters determine the availability of nitrogen to plants and markedly influence ecosystem productivity. Research priorities, which may lead to a manipulation of the ecosystem to increase plant growth and/or to reduce nitrogen losses from the plant environment, are discussed, with emphasis on agricultural systems. The principles are relevant for natural ecosystems.

INPUTS Except for the most intensive grasslands, the important role of the Rhizobium-legume symbiosis is unquestioned. Genetical research and breeding programmes for both the legume and the rhizobium have considerable potential for promoting a more effective symbiosis, under suitable agronomic conditions. Reliable methods for estimating field fixation rates and for detecting cross-contamination of rhizobia in any seed inoculation work are essential.

Where fertilizer N is being applied, the proportion taken up by the plant is a major productivity and economic factor. For fodder and grain legumes the response to fertilizer N should be compared with any associated reduction in nitrogen fixation. Crop breeding has considerable potential for increasing the efficiency of the uptake of fertilizer and soil nitrogen by cereals, grasses etc.

OUTPUTS Denitrification, possibly associated with nitrification in aerobic zones, can be a major factor influencing nitrogen availability to plants. Leaching and drainage, particularly of nitrate but also of organic nitrogen, are losses from the root region also requiring assessment. Methods for reducing losses of ammonia from plant and soil surfaces and particularly from animal liquid and solid excreta justify investigation. The quantitative estimate of these losses can be difficult.

CATCHMENT STUDIES Nitrogen budget studies in a defined area can be valuable for determining the fate of nitrogen entering the ecosystem and the possible overall effects of larger nitrogen inputs. These studies can also lead to the avoidance of the pollution of water and the atmosphere, and the effective management of many waste resources.

Regional Nitrogen Budgets: Approaches and Problems

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Nutrient budgets provide a useful and convenient context for organizing our current understanding of biogeochemical cycles. Budgets for nitrogen have been constructed for a large variety of ecosystems, and have lent considerable insight into the processes controlling nitrogen fluxes within and through these systems. In recent years several budgets for large geographic regions, up to and including the entire globe, have appeared. The present paper presents a brief discussion of the usefulness of such budgets, approaches taken in their construction, and problems with the resulting models. Particular attention is given to the special problems associated with the construction of tropical budgets.