codex alimentarius commission

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

WORLD HEALTH ORGANIZATION

JOINT OFFICE: Viale delle Terme di Caracalla 00100 ROME Tel: 39 06 57051 www.codexalimentarius.net Email: codex@fao.org Facsimile: 39 06 5705 4593

AGENDA ITEM NO. 5 **CX/FL 04/5-ADD.1**

E

JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON FOOD LABELLING
THIRTY-SECOND SESSION
MONTREAL, CANADA, MAY 10 – 14, 2004

GUIDELINES FOR THE PRODUCTION, PROCESSING, LABELLING AND MARKETING OF ORGANICALLY PRODUCED FOODS:
DRAFT REVISED ANNEX 2 – PERMITTED SUBSTANCES
(ALINORM 03/22A, APPENDIX VI & CL 2003/28-FL)

GOVERNMENT COMMENTS AT STEP 6

JUSTIFICATION BASED ON CRITERIA USE OF NATURAL SODIUM NITRATE IN ORGANIC FARMING

SANTIAGO, CHILE

CODEX DOCUMENT

JUSTIFICATION BASED ON CRITERIA

USE OF NATURAL SODIUM NITRATE

IN

ORGANIC FARMING

Santiago, Chile

February, 2004

FOREWORD

This document was written to be presented to the CODEX ALIMENTARIUS Committee on Food Labelling . It contains the technical justification supporting the request from the Delegation from Chile to include the Natural Sodium Nitrate in the list of accepted sources of nitrogen for organic crops.

During the 31st Session of the CODEX ALIMENTARIUS Committee on Food Labelling, Ottawa, Canada, April 28 – May 2, 2003, it was agreed that the Delegation from Chile would present this document for consideration at the 32nd Session of the Committee on Food Labeling (ALIFORM 03/22A, para. 88).

The structure of this document follows the same structure of concepts set up by CODEX in order to incorporate new substances into the list of approved Substances for Use in Soil Fertilizing and Conditioning (APPENDIX V, ALINORM 03/22A p. 44). The content follows the concepts in Section 5 "requirements for inclusion of substances in Annex 2 and criteria for the development of lists of substances by country" , that are grouped into two subsections, 5.1 General Criteria, and, 5.1 (a) Used for fertilization, soil conditioning purposes. Subsection 5.1 deals with the necessity for the substance to be consistent with the basic principles of organic farming. This document presents accepted technical evidence, knowledge and facts supporting the consistency of using Natural Sodium Nitrate with the principles of organic farming. Technical evidence regarding the benefits of using Natural Sodium Nitrate and organic N sources on yield and quality of organic crops is presented in subsection 5.1 (a). The natural origin of the substance, potential effects on the ecosystem and some use restrictions are also presented in this subsection.

An additional document where the benefits of Natural Sodium Nitrate are presented with more details will be available before de 32nd CODEX Meeting.

MATRIX FOR EVALUATION OF SUBSTANCES AGAINST CRITERIA

Substance to be used for fertilization, soil conditioning purposes.

Scoring: ++ very positive; + positive; 00 not to evaluate; - rather negative;

- - very negative

Proposed substance: Natural Sodium Nitrate (NSN) as source of nitrogen for crops in organic farming.

Section 5.1 General Principles

Criteria	Evaluation Against Criteria	Score	Proposed by
Consistent with principles of organic farming	The Natural Sodium Nitrate (NSN) is a natural substance extracted from the Caliche ore present in the inert surface of the Atacama Desert. It is extracted by mechanical and hydraulic processes, but not subjected to chemical processes. The NSN is a complementary source of N to the organic N sources, it promote biodiversity and increases the biological activity by delivering available N when the organic sources can not do it. The NSN helps to keep soil fertility for the future by facilitating the decomposition and humus formation from organic substances with high carbon content with respect to nitrogen (high C / N ratio). It does not harm the environment when properly used.	++	
Necessary for intended use	The NSN supplies nitrogen in a form that is directly absorbed by plant roots with no need of biological transformations. Its nitrogen is readily available during all growing seasons, in particular when climatic conditions prevent the transformation of organic nitrogen needed to release available N. The sodium provided by NSN helps to prevent soil acidification resulting from decomposition of organic substances and it is a nutrient for halophytic crops (sugar beets, vegetable species rape, asparagus, forage crops), The NSN also supplies small but significant quantities of Potassium, Magnesium, Sulfur and microelements Cooper, Boron, Manganese and Iodine.	+ / ++	
Manufacture, use and disposal does not result in, or contribute to harmful effects on the environment	The Atacama Desert is an extremely dry region with less than 2 mm rainfall per year, no surface soil, no trace of living organisms and no soil forming process. The NSN is extracted by water solutions but no liquid effluents leave the plants. Water is lost only by solar evaporation used to concentrate solutions. Solar radiation is a main source of energy and the quantity captured cover 57% of the total energy used in the extraction process. Use of NSN for more than 80 years under experimental conditions (UK) and in farming (Japan) and for more than a 100 years elsewhere has shown not a trace of negative effects on the environment. The NSN does not loss it proprieties over time and should not be disposed but properly stored for subsequent crops.	+	
It has the lowest negative impact on human or	All forms of organic N are transformed in the soil to the ammonium and nitrate forms. These are the only forms of N that are absorbed by plants. Hence, the nitrate N	+	

animal health and quality of life	present in the Natural Sodium Nitrate is of the same nature as that resulting from organic transformations. No harm may be expected to soils, crops animals and quality of life when used according to soil and crop needs. Sodium is also a natural constituent in the soil profile, and sodium rates applied with NSN are well within the natural range of Sodium in normal soils. Being an alkaline element it contributes to maintain the pH at a favorable level, not affecting the biological life. Content of Cadmium, Arsenic, Chrome and Lead in NSN is less than one mg kg-1. This levels are among the lowest in natural fertilizers.		
Approved alternatives are not available in sufficient quantity or quality.	NSN is the only natural non-organic substance that provides N in the nitrate form, that is available to crops with no need of biological transformations that depend on temperature and other soil conditions.	+	

Section 5.1 (a) Use for fertilization, soil conditioning.

Criteria	Evaluation Against Criteria	Score	Proposed by
Essential for obtaining or maintaining fertility of the soil or fulfill specific nutrition requirement of crops, soil conditioning and rotation purposes which cannot be satisfied by the practices included in Annex 1, or other products included in Table 2 of Annex 2.	Nitrogen is an essential element for soil fertility and crop production. All organic N needs to be transformed into ammonium and nitrate forms to be absorbed by plant roots. The transformation is driven by soil microorganisms and depends on soil temperature, pH, moisture and other proprieties. Research has shown that the quantity of N provided exclusively by organic sources is less than the N required to produce acceptable yield and quality of crops. This is because (a) insufficient level of total N in organic sources, and, (b) lack of synchronization between the rate of transformation of N from organic sources and the rate of uptake of N by plant roots along the growing season. This often results in leaching of the N from the organic sources. NSN supplies N that can be immediately absorbed by plants, allowing to control the quantity of N to be applied and the timing of the application, thus synchronizing the N supply to the specific plant nutrition requirement.	+	

Ingredient is of plant, animal, microbial or mineral origin; may undergo the following processes: physical (mechanical, thermal), enzymatic or microbial (composting, fermentation); only when the above processes have been exhausted, chemical processes may be considered and only for the extraction of carriers and binders.	NSN is extracted by leaching the ground Caliche ore with a weak salt solutions at 40-45 ^{o}C.. After leaching the ore the solution is cooled to 12 ^{o}C to precipitate NSN . The wet NSN is dried, granulated and stored or dispatched to be used as a source of N for crops. After precipitating the NSN, the weak solution is further concentrated in ponds at the solar evaporation system before entering a second salt precipitation cycle. Chemical N fertilizers use an average of 40 Giga Joule (G J) per 1 ton of N .The process to extract NSN uses a total of 44 GJ, being close to the average of the industry. The solar energy captured by the system is equal to 25 G J per 1 ton of N (6.25 ton of NSN). This is equal to 57% of the total energy consumption, and represents a large saving of non-renewable energy.	++	
Their use does not have a harmful impact on the balance of the soil ecosystem or on the soil physical characteristics, or water and air quality.	Use of Natural Sodium Nitrate for around 80 years in experimental conditions (UK) and in farming in Japan, and even more in USA and other countries has not shown any negative effect on the environment. Also nitrate N from NSN does not volatilize as it is the case with ammonia nitrogen.	+ / ++	
Use may be restricted to specific conditions, specific regions or specific commodities	Use of Natural Sodium Nitrate is not recommended in saline or sodic soils. These soils conditions can be easily identified by determinations done on samples sent to soil test laboratories. It use is also not recommended in soils with poor internal drainage and in dry land farming with low rainfall and no access to irrigation water. In the USA the use of NSN is restricted to supply 20% of the crop nitrogen requirement.	+	

SUMMARY

The use of Natural Sodium Nitrate (NSN) that contains 16% Nitrogen and 26% Sodium as a source of nitrogen (N) for organic crop is consistent with the basic principles of organic farming according to facts and concepts known for many years as well as because of recent research results discussed and referred to in this document. The NSN promotes the biodiversity and increases the biological activity by providing available N when the organic sources can not provide N. NSN also helps to keep soil fertility for the future by promote the transformation and humus formation from organic substances having high levels of Carbon with respect to Nitrogen (high C/N ratio). The supply of natural Sodium helps to prevent soil acidification, being beneficial to halophytic crops (sugar beet, vegetables and pastures). The NSN also supplies small but significant quantities of Potassium, Magnesium and Sulfur, as well as microelements Copper, Boron, Manganese and Iodine, essential for crops. Content of contaminants Cadmium, Arsenic, Chrome and Lead are less than 1 mg kg^{-1} . This levels are among the lowest in natural fertilizers.

NSN is a natural substance extracted using mechanical and hydraulic processes not including chemical reactions. It is the only natural source of nitrate nitrogen that, together with ammonium nitrate, are the two only chemical forms that can be absorbed by plant roots. Because Natural Nitrate has a ready available form of N, it is a complement to organic N sources that need time and favorable ecological conditions to be transformed by soil microorganisms into available N for plant roots. The factors that limit the release of available N from of organic sources have the same effect on organic sulfur (S) sources, as the organic and chemical behavior of both nutrient elements are similar. However the limitations of organic S are not a problem for organic farmers because natural non-organic sources of S are permitted to be used in organic farming. This implies an asymmetric handling of this two similar nutrients in organic farming.

Formation of NSN existing today in the Atacama Desert dates back 200.000 years. The Atacama Desert is the driest desert on earth with less than 2 mm of rainfall per year. There is no soil on the surface of the Desert, no soil formation process, nor any trace of life or biological life precursor, to the point that for NASA the Desert is similar to the inert surface of Mars. The origin of the NSN is supposed to be promoted by atmospheric conditions.

No liquid effluents leave the mining facilities. All solutions are recycled and water is lost only to the atmosphere in the solar evaporation system, a very important component of the mining process.

Proper use of NSN together with best management practices guarantee the absence of negative impact on human life and on the environment. With respect to other natural substance that could provide available N to organic crops, the fact is that there is no known alternative to NSN that is a natural substance and supplies available nitrate N to crops without the need to undergo organic transformations.

Recent field and laboratory investigations conducted by institutions well related to the organic farming community have demonstrated that the sole use of organic N sources do not allow to obtain expected good yield and quality of produce. This is primarily because (a) sub-optimum quantities of available N released by soil microorganisms from organic sources, and, (b) lack of synchronization of the rate of release of available N with the uptake timing of growing. This is important for organic farmers in particular during cold seasons and for farmers located in temperate and cold regions, as it has been demonstrated by recent research in Europe and the USA. Not only are organic farmers affected but also consumers may not find the organic produce of their preference during certain times of the year. NSN provides a solution by supplying available N for crops during all seasons and under most diverse soil, climate and management conditions.

NSN is obtained from the Caliche ore in the Atacama Desert by mechanic and hydraulic processes that do not pollute the environment, and where the sun light

plays an essential role as a source of energy. The solar energy captured by the system is equal to 25 GJ per 1 ton of N (6.25 ton of NSN). Chemical N fertilizers use an average of 40 Giga Joule (G J) per 1 ton of N, and the process to extract NSN uses a total of 44 GJ, being close to the average of the industry. However, in the NSN extraction, only 19 GJ of non-renewable energy are used, equivalent to 43% of the total energy consumed, whereas the remaining 57% is solar energy. The Natural Sodium Nitrate is not only of natural origin, but also the largest proportion of the energy used for extraction is renewable energy.

Use of Natural Sodium Nitrate is not recommended in saline and sodic soils, whose chemical conditions are easily identified by routine analytical determinations in samples sent to soil test laboratories. Its use is also not recommended in soils with poor drainage or in arid soils with limited rainfall and no irrigation. Under these conditions most crop inputs should be also subject to some use restrictions.

In the USA, the use of Natural Sodium Nitrate is restricted to 20% of the N required by the crop being grown.

The concepts presented in this document as well as related matters are presented with more details in a complementary document that will be available before the 32nd Meeting of the Committee of Codex Alimentarius.

CONTENTS

PROPOSED SUBSTANCE: Natural Sodium Nitrate as a source nitrogen for organic crops.

SECTION 5. REQUIREMENTS FOR INCLUSION OF SUBSTANCES IN ANNEX 2 AND CRITERIA FOR THE DEVELOPMENT OF LISTS OF SUBSTANCES BY COUNTRIES.

SECTION 5.1 General Principles

5.1-1. Consistent with the principles of organic production.

The use of Natural Sodium Nitrate (NSN) together with organic nitrogen sources in organic crop production is consistent with the principles of organic production because it is a natural substance not subject to chemical treatments and it is environmentally friendly when properly used. The NSN is found in the Caliche ore on the inert surface of the Atacama Desert, in Northern Chile, and it is extracted by using mechanical and hydraulic processes, not being subject to chemical processes. NSN promotes the biodiversity and increases the biological soil activity by providing nitrogen when little or no N can be released from the organic sources. NSN promotes the long term soil fertility by facilitating the transformation and humus development from organic substances that have high levels of Carbon (C) with respect to N (high C/N ratio), and it does not harm the environment when properly used. Natural Sodium Nitrate provides available nitrogen to growing crops when the soil biological system cannot transform organic nitrogen into available forms or when the transformation rate is at a lower rates than it is needed by the plants. This process has two steps: transformation of organic N into ammonia or “mineralization” and oxidation of ammonia to nitrate or “nitrification”. The term transformation will be used to include both steps. Field conditions that affect the activity of soil microorganisms follow (Brady & Weil, 1999. p. 499-502).

- low soil temperatures,
- soil acidity or alkalinity,
- wide Carbon to Nitrogen (C/N) ratio in organic substances,
- sub-optimum moisture or oxygen soil levels,
- presence of smectite or allophane clays, and,
- other situations that may prevent the normal activity of soil microorganisms..

5.1-2. Substance is necessary / essential for its intended use.

Availability of Soil Nitrogen for Plant Growth.

Natural Sodium Nitrate is a needed complement to organic nitrogen sources in organic farming, as a provider of the ready available NO_3^- - N form. In addition to provide NO_3^- - N, the Natural Sodium Nitrate also supplies needed secondary and trace elements. Nitrogen in soils is present in different chemical forms, most of it in organic compounds. But only a very small fraction of total soil nitrogen – the inorganic or "mineral" forms NO_3^- and NH_4^+ – are the major sources of inorganic nitrogen taken up by the roots of higher plants (Mengel & Kirkby, 1987. p. 347, 366). Soil microorganisms are responsible for the decomposition of organic substances and the transformation of organic nitrogen into inorganic or mineral forms (Brady & Weil, 1999. p. 449-460). With few exceptions, the highest plant growth rate, yield and quality is achieved when plants absorb most of the nitrogen as NO_3^- - N and the rest as NH_4^+ - N (Marschner, 2002. p. 247-250). Some of the most important factors affecting microbial transformations that release nitrate N from organic substances in soils are briefly reviewed in following sections.

Effect of Temperature. During cold seasons – that in many agricultural regions of the world correspond to late fall, winter and early spring – soil microbial activity is very low or almost absent. Since most biological reactions are influenced by temperature, it is consistent that nitrification is also influenced by this environmental factor. The temperature coefficient Q_{10} of nitrogen mineralization is equal to 2 over the range 5 ^oC to 35 ^oC. Thus a twofold change in the mineralization rate is associated with a shift in 10 ^oC within this temperature range. Below 5 and above 40 ^oC the rate of nitrogen mineralization usually drops off, with the optimum commonly lying between 30 and 35 ^oC (Tisdale, Nelson, Beaton & Havlin, 1985 p.134-135). At 10 ^oC the microbial activity may decrease to less than 25 % of the normal rate , and the concentration of NO_3^- and $NH4^+$ in the soil resulting from the slow decomposition of organic substances is not enough to produce the quantity and quality of vegetables demanded by consumers of organic products (Hebeisen, Ballmer, Torche & Reust, 2003; Havlin, Beaton, Tisdale & Nelson, 1999; Nat. Organic Standards Board Tech. Advisory Panel Review, 2002; Small Planet Food, 2002)

The converse effect may occurs in warm seasons during late spring and summer when mineral nitrogen in excess of crop demand could be released from organic substances. This excess mineral nitrogen may be leached and could contaminate underground water, thus becoming harmful to the environment. It is not possible to store available nitrogen in the soil for cold and / or wet seasons. Depending on the level of soil moisture, the mineralized nitrogen that remains in the soil profile after harvesting crops during summer or fall is either leached to the subsoil, reduced to the form of gas N_2 and released to the atmosphere or it is absorbed by soil microorganisms (Blankenau, Klaus. 2000). In the first two cases, the nitrogen leaves the soil profile and it is no longer available to subsequent crops. In the third case Nitrogen absorbed by microorganisms remain in the soil as an organic compound during the cold season until their decaying bodies are mineralized by subsequent generations of microorganism in the next warm season.

Effect of pH. Soil pH is a factor that restricts the activity of microorganisms responsible for organic transformations in soils. The range of soil reaction over which nitrification takes place has been given as pH 5.5 to about 10, with the optimum around 8.5. But some nitrification takes place at pH 4.5 or lower. (Tisdale, Nelson & Beaton, 1985 p. 129). The continuous transformation of organic substances is in itself a factor increasing soil acidity as a result of the hydrogen ions H^+ released during the transformation of the organic nitrogen. One hydrogen ion H^+ is released to the soil for each NO_3^- nitrogen ion that result from the transformation. (Tisdale, Nelson & Beaton, 1985. p. 127).

Carbon to Nitrogen ratio (C/N). The transformation of organic N into available N by microorganisms is affected by the C/N ratio of the substance being added to the soil. If the substance has a C/N ratio lower than 20/1, the organic transformation takes place and available N is released to the soil. However, if the C/N ratio is greater than 30/1 the imbalance due to the excess of carbon prevent the transformation to take place, unless there is available N in the soil to be used by microorganisms. The net result is a decrease or immobilization of soil available N. For ratios between 20/1 and 30/1 there may be neither release nor immobilization of available N (Tisdale, S.L., et al., 1993. p. 124-125).

Sub-optimum moisture or oxygen soil level. Soil moisture content regulates the quantity of oxygen in the soil and the proportion of aerobic and anaerobic microbial activity. Nitrate

nitrogen can be produced by transformation of organic substances in the soil only under aerobic conditions. Maximum aerobic activity and nitrate formation occurs when 50 – 70 % of soil pore space is filled with water, the remaining space providing air circulation for oxygen supply. Water levels outside this range result in a moisture – oxygen imbalance that reduce nitrate formation, that eventually may result in nitrate N deficits in soils (Havlin, J.L. et al., 1999. p. 108-109).

Type of clay. Smectites and allophanes have been found to stabilize soil organic matter and to reduce rates of nitrate N formation in soils. Nitrogen-containing organic components become bonded to the clay surfaces or are found in tiny inter-micelle pores and are thereby protected from microbial attack (Brady & Weil. 1999).

Similarity of the Nitrogen and the Sulfur Cycles.

The element sulfur (S) has a "natural cycle" similar to the nitrogen cycle, being absorbed by plants and soil microorganisms as the sulfate sulfur chemical form. At early stages of soil formation, decomposing minerals in the parent material provided soluble sulfate to the soil solution. In recent times, atmospheric sulfur dioxide , product of burning fossil fuel, has been brought down by rainfall and incorporated into the soil profile after being oxidized to the sulfate form .

Plants and soil microorganisms reduce the absorbed sulfate sulfur and the resulting molecules form organic compounds that are part of the living tissue. Since this stage on, the S molecules enters into a cycle similar to that of N, as decomposing organic substances represent a natural supply of S to farming soils. Given that the excess sulfate can be leached from the soil profile, little or none of it remains from the parent material in mature soil profiles. And because increased public concern about atmospheric pollution, the supply of sulfate sulfur from the atmosphere also has been reduced substantially. Consequently, the decomposition of organic substances represent today the main source of sulfate sulfur, in the same way as it represent the main source of nitrate nitrogen in organic farming.

Notwithstanding the organic and chemical similarities between the sulfate and nitrate forms both elements are treated very different from a practical standpoint. While accepting that deficiencies of sulfate - product of insufficient supply by decomposing organic

substances - can be corrected by application of non-organic natural sources of sulfate sulfur, the same practice is not allowed for the case of nitrate deficiencies, in particular by rejecting the use of Natural Sodium Nitrate . Reasons for the asymmetrical treatment of this two plant nutrients of similar behavior could not be found in a throughout review of the world related literature.

The Natural Sodium Nitrate : a complementary N source in Organic Farming.

Supply of natural nitrate N. NSN is the natural substance that complement all sources of organic nitrogen in organic farming by providing available nitrate N that can be immediately absorbed by crops as well as significant quantities of needed secondary and trace elements. Furthermore the quantity of sodium applied with the NSN contributes to neutralize soil acidity, including that resulting from the acidifying effect of the decomposition of organic substances (Pinilla, 1993).

Supply of Trace Elements. A sufficient supply of secondary and trace elements is relevant for the N fertilizer efficiency. Deficiencies of sulfur (S), K, Mg, Zn, Cu and B may result in a low N fertilizer efficiency of 19 – 32 % compared to 74% under optimum nutrient supply (Schnug, 1991). An application of 35 kg N ha^{-1} (220 kg NSN ha^{-1}) supplies 20% of boron needs, 25% of manganese needs, 10-15% of Cu needs, 1-2% of sulfur needs, plus 450 and 1000 g ha-1 of magnesium and potassium, respectively.

5.1-3. Mining, use and disposal does not result in, or contribute to harmful effects on the environment.

Characteristics of the Natural Sodium Nitrate Region.

Chilean nitrate is a natural component of the Caliche ore in the Atacama Desert, located 1500 km north of Santiago. The Atacama Desert is one of the driest regions in the world that receives less than 2 mm of rainfall per year. The rainfall water evaporates almost immediately leaving the desert surface in a permanent dry condition. Lack of moisture is

a critical condition that has permitted the NSN to remain in the superficial Caliche layer of the Desert for more than 200.000 years without a trace of leaching (Ericksen, 1981).

Absence of Soils and of Processes of Soil Formation.

The natural dry condition of the Atacama Desert has another important consequence. The lack of moisture has prevented the weathering of the surface rocks (parent material) and the development of living organisms (microbial, vegetal, animal, Human) two main factors in the process of soil formation and as a direct consequence, no soil development process has ever occurred in the Atacama Desert. Microbial and vegetal life can be found only in a few sites where moisture is available from ground water or brought in from the mountains for mining purposes. In Soil Science, early field studies by V.V, Dukochaev in the late-19th-century followed by the work of Hans Jenny during the 20th-century and by much careful subsequent field and laboratory research led to the recognition of five major factors that control the formation of soils (Brady, N.C. & R.R. Weil, 1999).

1. Parent material (geological or organic precursors to the soil)
2. Climate (primarily precipitation and temperature)
3. Biota (living organisms, vegetation, microbes, soil animals, and human beings)
4. Topography (slope, aspect, and landscape position)
5. Time (period of time since parent material became exposed to soil formation).

Soils are defined in terms of this factors as “dynamic natural bodies having properties derived from the combined effect of climate and biotic activities, as modified by topography, acting on parent materials over periods of time”. As a consequence of the lack of moisture and living organisms, no soil exists today in the Atacama Desert and also no evidence of buried soils has been found. The surface of the Desert is covered only by dust and rocks and it has never been subjected to a weathering process.

This particular kind of surface in the Atacama Desert has attracted NASA to test its Moon and Mars landing vehicles and research procedures. In a recent publication in Science Magazine (Navarro-Gonzalez, R., Rainey, F.A. & others, 2003), a team of scientist from Louisiana State University, NASA and the Universidad Nacional Autonoma de Mexico report the discovery of an area of Earth that is shockingly similar to the surface of Mars. NASA´s Vicking mission to Mars in the 1970s showed the martian soil to be lifeless and depleted in organic materials, the chemical precursors necessary for life. Last year, in the

driest part of the Atacama Desert, microbe hunting experiments similar to Vicking´s were conducted by the research team and no evidence of life was found.

Extraction of Natural Sodium Nitrate and the Use of Water.

During the extraction process, the Caliche is crushed and the Chilean nitrate is lixiviated under controlled conditions with a 35-40 ^{o}C weak salt / water solution and subsequently separated from the solution by crystallization at a lower temperature. Available water for the extraction process is very limited and originates in the Andes Mountains, hence all water solutions are recycled. The only loss of water is by evaporation from large ponds where the solutions are concentrated year-round by solar energy. No liquid effluents result from the whole extraction process.

Use of the Natural Sodium Nitrate .

With respect to it use, when Natural Sodium Nitrate is applied to crops it is possible to exert a high level of control over the quantity and timing of the resulting level of available nitrate in the soil. Experiments using labeled nitrogen ^{15}N demonstrated that split applications of Natural Sodium Nitrate can be synchronized with the rate of nitrogen uptake by the crop thus minimizing the available nitrate left in the profile after harvest that may be subject to lixiviation and be harmful to the environment (Riga, A., et al., 1988). With respect to the sodium content in Natural Sodium Nitrate , this fertilizer has been applied in the Rothamsted Classical Experiment for around 100 years without damaging the soil (Cooke, 1982). This subjects will be discussed in subsequent sections of this document.

Disposal.

Considering how useful the Natural Nitrate is for crop production, it should not be disposed and it can be stored for longer periods for subsequent cropping. No alteration of its characteristics takes place as long as fertilizer storage prescriptions are met.

Scientific and technical evidence shows that mining, proper use and storage of the NSN does not result in, or contribute to any harmful effects on the environment. This conclusion

is further supported by the historical fact that this substance has been safety used by farmers in many countries in different continents for more than a hundred years.

5.1- 4. Lowest negative impact on human or animal health and quality of life

When properly used as a source of N for crops, the Natural Sodium Nitrate does not have any negative effect on human or animal life and on the quality of the environment. If not used correctly, a negative impact of soil nitrates on human or animal health and quality of life may results when nitrates are leached to the subsoil and contaminate the groundwater. However, as indicated in # 5.1.3 above, nitrate leaching occurs only when it is not used properly, that is, when (a) the rate of application is far greater than what is needed according to crop and soil conditions, and, (b) the schedule of application and / or availability of the nitrogen in the soil is out of synchronization with the rate and timing of the nitrogen uptake by the crop being grown (Havlin et all, 1999; Riga et al, 1988; McGill & Myers, 1987). But, as explained elsewhere in this document, Natural Sodium Nitrate is the least contaminant among the natural sources of fertilizer nitrogen, provided that (a) the quantity being applied corresponds to the real need of the soil/plant system, and, (b) the timing of application is synchronized with the proper rhythm of nitrogen uptake by the plant along its growing cycle. Sodium is also a natural constituent of the soil profile, and the quantities of sodium applied with the NSN are well within the normal limits for Sodium in soils. Being an element with alkaline reaction, Sodium neutralizes the acidity produced by the decomposition of the organic substances added to the soil, thus decreasing the needed amount of lime. Furthermore Sodium is a nutrient for halophytic plants, with partial substitution of Potassium in Sugar Beet and other species. The content of heavy metals in NSN is quite low. Content of Cadmium, Arsenic, Chromium and Lead is less than one mg kg^{-1}. The total heavy metal content expressed as Lead is less than 5 mg kg^{-1}. This levels are among the lowest in natural fertilizers.

.

5.1-5. Approved alternatives are not available.

As discussed elsewhere in this document the biological release of nitrate and ammonia - the two N forms that can be absorbed by crop - from organic substances in soils is

severely limited by (a) the relatively low N content in organic substances, (b) the low soil temperature during cold seasons, and, (c) other soil and climatic conditions. The limiting effect of low temperature on transformation of organic N is an inevitable consequence of the normal dependence on temperature of earthbound biological systems. Those natural conditions cannot be controlled in open fields, contrary to the control that can be exerted in, for example, greenhouses or other special production systems. Only nitrogen forms that are available to plants without the need to undergo biological transformations in soils can feed growing crops during all seasons as well as during unfavorable soil and climatic conditions. Natural Sodium Nitrate is the only non-synthetic nitrogen source - naturally occurring and subjected only to mechanical but not chemical treatments - that provides the needed nitrogen supplement within the definitions of Organic Agriculture. The use of this natural source of N allows large areas under organic farming system around the world to continue their year-round production of organic produce. The ultimate beneficiary will be the consumers of organic produces as they can count on a steady supply of organic farm products year-round.

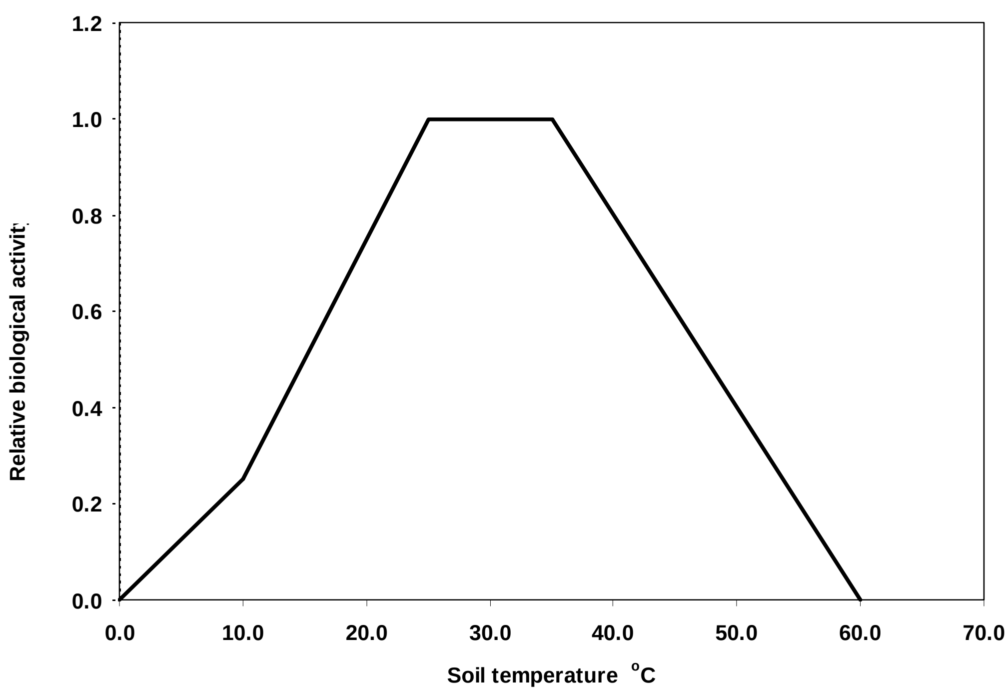
SECTION 5.1 (a) Substances used for fertilization, soil conditioning.

5.1 (a)-1. Essential for obtaining or maintaining fertility of the soil or to fulfill specific nutrition requirements of crops, soil conditioning and rotation purposes which cannot be satisfied by the practices included in Annex 1, or other products included in Table 2 of Annex 2.

Transformation of Organic Nitrogen.

All forms of organic nitrogen, from legume cover crops, compost, manure, animal and fish residues, etc., need to be naturally transformed in the soil into mineral, i.e., non-organic, nitrogen forms, mainly nitrate nitrogen, in order to be up taken by plant roots. The transformation is driven by soil microorganism and it is dependent among other factors, on soil temperature, pH and aeration. When soil temperature is below 12 ^{O}C, the relative soil microbial activity is less than 25% as indicated in Fig 1 (Doran & Smith, 1987).

FIG 1. Effect of soil temperature on the relative biological activity



Source: Doran,J.W. & M.S. Smith. 1987. Organic matter management and utilization of soil and fertilizer nutrients. In Follet, R.F. & others. Soil fertility and organic matter as critical components of production systems. Madison, WI, USA, SSSA Special Publication No. 19. p. 53-72

At this soil temperature not enough NO_3^--N becomes available to satisfy the needs of a healthy crop growing in late winter or early spring.

Sufficient nitrate NO_3^--N cannot be stored in available form in the soil profile during late summer and fall. During late fall, winter and early spring most nitrate leaching occurs in humid temperate and Mediterranean climates (Brady & Weil. 1999. p. 505). Part of the soil nitrate NO_3^--N can be also absorbed by soil microorganisms (Blankenau, Klaus. 2000. p 25-45) and it is not released until the next warm growing season when their decaying bodies are mineralized. The first and most visible effects of limited mineral nitrate in crop production are the reduction in crop yield and quality parameters.

Organic N Supply: Effect on Yield and Quality of Wheat - Switzerland.

In a long-term seven year rotation experiment including the following crops, red clover/grass, red clover/grass, potato, winter wheat, cabbage or rape, winter wheat, and winter rye, two growing methods were compared, conventional and organic. The conventional method included mineral and organic fertilizer (integrated norm) whereas the organic method included only organic sources of nutrient elements.. After completing the third rotation cycle, the average yield of the organically grown wheat was only 86% of the conventionally grown wheat. Yield of organically grown potatoes was only 63% of conventionally grown potatoes. (Dubois, D. et al, 2003).

The result of a two years variety trial cultivated under organic and conventional cropping systems is presented in Table 1. In this experiment, the average yield of all varieties receiving organic manure is 20% less than the average yield of the same varieties receiving conventional fertilizers. Also the average protein content for the organic treatment is 11% lower than the protein content for the conventional treatment.

TABLE 1. AVERAGE YIELD AND PROTEIN CONTEN OF CONVENTIONAL AND ORGANIC GROWN WINTER WHEAT VARIETIES. 2000 AND 2001.

Wheat	Grain Yield				Protein Content			
Variety	Conventional	Organic	Difference		Conventional	Organic	Difference	
	mt ha^{-1}	mt ha^{-1}	mt ha^{-1}	%	%Pc	%Po	%Pc-%Po	%Diff
Arina	5.81	4.89	0.92	15.83	13.6	12.1	1.5	11.0
Tamara	5.81	4.45	1.36	23.41	14.3	13.4	0.9	6.3
Runal	6.22	4.98	1.24	19.94	14.2	12.6	1.6	11.3
Lona	5.91	4.57	1.34	22.67	14.1	12.5	1.6	11.3
Titlis	6.32	5.19	1.13	17.88	14.5	12.6	1.9	13.1
Taneda	6.56	4.81	1.75	26.68	14.0	12.9	1.1	7.9
Levis	7.14	5.31	1.83	25.63	13.0	11.4	1.6	12.3
Pegassos	7.52	6.62	0.90	11.97	11.8	9.9	1.9	16.1
Average	6.41	5.10	1.31	20.41	13.7	12.2	1.5	11.1

Source: Menzi, M. & M. Anders. 2003. Essais varietaux de cereales dans les conditions de lágriculture biologique. Zurich-Rekenholz, Swiss, Station federale de recherches en agroecologie. Les Cahiers de la FAL 45, pp 24-29

And the most significant effect of the organic treatment, besides the reduction of grain yield and protein content is their compound effect resulting in the reduction of the vegetal protein produced per unit of cultivated area. Table 2 shows the combined effect of lower yield and lower protein content on the yield of protein per unit area, as well as the results of the sedimentation Zeleny test.

TABLE 2. PROTEIN YIELD AND SEDIMENTATION ZELENY TEST OF CONVENTIONAL ANI ORGANIC GROWN WINTER WHEAT VARIETIES. AVERAGE 2000 AND 2001.

Wheat	Protein Yield				Sedimentation Zeleny Test			
Variety	Conventional	Organic	Difference		Conventional	Organic	Difference	
	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	%	ml	ml	ml	%
Arina	790	592	198	25.1	54.3	50.8	3.5	6.4
Tamara	831	596	235	28.2	71.3	64.5	6.8	9.5
Runal	883	627	256	29.0	62.5	57.5	5.0	8.0
Lona	833	571	262	31.4	66.3	58.0	8.3	12.5
Titlis	916	654	262	28.6	67.5	59.5	8.0	11.9
Taneda	918	620	298	32.4	65.9	62.3	3.6	5.5
Levis	928	605	323	34.8	60.4	51.8	8.6	14.2
Pegassos	887	655	232	26.1	54.6	41.2	13.4	24.5
Average	873	615	258	29.6	62.9	55.7	7.1	11.4

Source: Menzi, M. & M. Anders. 2003. Essais varietaux de cereales dans les conditions de lägriculture biologique. Zurich-Rekenholz, Swiss, Station federale de recherches en agroecologie. Les Cahiers de la FAL 45, pp 24-29

The protein yield decreases an average of 258 kg ha^{-1} or 30% less for the organic treatment as compared to the conventional one. Further, the sedimentation Zeleny test for the organic treatment is 11.4% lower. The decrease in both, the protein content and the sedimentation test have an important negative effect in the baking quality of the flower and in the bread, and this should be reflected in the price the organic farmer is being paid for his wheat. Also, for the consumer of organic products, the importance of organic wheat as an additional source of vegetal proteins is being substantially decreased.

Organic N Supply: Effect on Yield and Quality of Potato - Switzerland.

In the long term rotation experiment quoted in the previous Wheat section, yield of potatoes receiving permitted organic fertilizers was only 63% of the yield of potato fertilized with organic and mineral fertilizer under the integrated PER program. The PER program is defined as Low Input Integrated Production Agriculture with some additional land used for “ecological compensation” i.e., a production system relatively close to organic agriculture (Dubois, D. et al, 2003).

A group of potato variety trials cultivated under organic and PER systems during the four seasons since 1997/1998 to 2000/2001 (Hebeisen et al, 2003) confirmed the results by Dubois et all (2003). The results of this variety trials are presented in Table 3.

The average yield over the four seasons for all potato varieties in the trials cultivated under the PER system was 34.4 mt ha^{-1} whereas the average yield under the organic system was 18.9 mt ha^{-1}. The average yield under the organic system is only 55% of the yield attained with the PER system.

In Table 3 it is also important to note that despite normal yield differences that should be expected among varieties and seasons, the ratio of the yield under organic system with respect to the yield under the PER system remains almost constant at 0.55 or 55% during all four experimental seasons.

TABLE 3. AVERAGE POTATO COMMERCIAL YIELD FROM VARIETY TRIALS 1997 - 2001.

Year	Variety	Organic norms mt ha^{-1}	PER norms mt ha^{-1}	Org / PER %
1997/1998	Marabel	19.3	40.6	47.5
	Velox	21.9	33.1	66.2
	Sirtema [1]	23.5	38.1	61.7
	Bintje [1]	18.0	36.9	48.8
	Average	20.7	37.2	55.6
1998/1999	Victoria	17.5	37.1	47.2
	Appel	20.2	36.1	56.0
	Bintje	18.0	29.6	60.8
	Average	18.6	34.3	54.2
1999/2000	Naturella	19.4	30.8	63.0
	Synfonia	21.7	34.4	63.1
	Bintje	11.3	30.7	36.8
	Average	17.5	32.0	54.6
2000/2001	Agata	22.3	34.8	64.1
	Cherie	18.2	31.5	57.8
	Laura	19.7	36.4	54.1
	Sistema	18.7	32.7	57.2
	Bintje	14.2	32.8	43.3
	Average	18.6	33.6	55.4
Overall average		18.9	34.4	55.1

[1]: Standard varieties.
Source: Hebeisen, Thomas, et al. 2003. Etude varietale pour la culture biologique des pommes de terre: le point de la situation. Zurich-Rekenholz, Swiss, Station Federale de Recherches en Agroecologie.
Les Cahiers de la FAL 45, pp 30-36

According to the authors (Hebeisen et al, 2003), the yield potential of potato varieties cannot be attained in full under the organic system mainly because of early diseases (blight) and insufficient nitrogen supply, that result in a weak development and an early senescence of leaves. Furthermore, even the blight tolerant varieties did not show a significantly higher yield.

As compared with other crops, potato has a relatively high need of nitrogen that must be satisfied in a rather short time period. According to Walther, 1990, and Walther et al, 1996, quoted by Hebeisen et al (2003), potato absorb 80% of the nitrogen within four to

six weeks after emergency. Further, because of the limited development of the root system, the supply of nutrients has to be concentrated in a rather small volume of soil.

With respect to the effect of the growing system on potato quality, the following observations were made on the results of the experiments (Hebeisen et al, 2003):

- Starch. The starch content was not different between the two growing systems. Consequently, the production of starch per unit of cultivated area for the organic system was almost one half of the starch produced under the PER system.
- Physical quality. Under the organic system more tubers were hollow and the sizes were above the commercial norms. This was due to the more restricted nutrient supply, nitrogen in particular.
- Marketing season. The organically grown potatoes matured early and consequently came earlier to the market than the conventionally grown potatoes of the same variety. This upsets the normal timing of the logistic chain and needs additional storage expenses.

Organic N Supply: Effect on Tomato Yield - California

Four crop rotations and management systems were studied in 1994 and 1995 in relation to growth and yield of irrigated processing tomatoes (*Lycoperswicon esculentum* Mill.) in the Sacramento Valley close to the Davis Campus of the University of California. The crop rotations were

1. conventional four-year rotations (conv-4);
2. conventional two-year rotation (conv-2);
3. low input four year rotation; and,
4. organic four year rotation.

Crops in the two four year rotations were tomato-safflower-corn-wheat (or oats+vetch) / beans). In the two year rotation the crops were tomato-wheat. In the conventional systems N was supplied as mineral fertilizer; in the low input system it was supplied as vetch green manure plus mineral fertilizer; and, in the organic system it was supplied as vetch green manure plus turkey manure. Application rates are in Table 4.

TABLE 4. RATE AND SOURCE OF NITROGEN APPLIED TO TOMATOES GROWN UNDER DIFFERENT FARMING SYSTEMS

Production system	Applied N (kg/ha)							
	1994				1995			
	Mineral fertilizer	Cover crop	Manure	Total	Mineral fertilizer	Cover crop	Manure	Total
Convetional-4	162			162	173			173
Coventional-2	162			162	173			173
Low input	95	111		206	95.0	64		159
Organic		103	130	233		82	125	207

Source: Cavero, J., Plant,R.E., Shennan, C. & D.B. Friedman. 1997. The affect of nitrogen source and crop rotation on the growth and yield of processing tomatoes. The Netherlands, Kluwer Academic Publ., Nutrient Cycling for Agroecosystems 42:271-282.

Tomato was direct-seeded in the two conventional systems. In the low input and organic systems it had to be transplanted because of the less complete weed control in those two systems. Tomato yields by years and production systems are in Table 5. During 1995 tomatoes grown with the low input and conv-4 systems had similar yields, which were higher than in the conv-2 and organic systems. The lower yield with the organic system in 1995 was caused by a N deficiency related to low level of mineralized N in the soil and to slow release of mineral N from the cover crop + manure. A high proportion of the N from the vetch green manure but only a low proportion of N from the turkey manure was mineralized during the season.

TABLE 5. TOMATO YIELD BY YEAR AND PRODUCTION SYSTEM

Production system	Tomato yield (mt ha^{-1}) 1994	Tomato yield (mt ha^{-1}) 1995	Mean yield mt ha^{-1}	Mean yield %
Convetional-4	92.9	74.5	83.7	100
Coventional-2	83.0	67.2	75.1	90
Low input	62.6	80.3	71.5	85
Organic	54.6	64.5	59.6	71

Source: Cavero, J., et al. 1997. The affect of nitrogen source and crop rotation on the growth and yield of processing tomatoes. The Netherlands, Kluwer Academic Publisher, Nutrient Cycling in Agroecosystems 42:271-282.,

A similar situation was observed in the Swiss wheat trial discussed earlier in this document. The low level of available N in the soil under the organic system was reflected in the low concentration of nitrate N measured in the petioles of tomato leaves at three different stages of plant development (Table 6).

TABLE 6. NO3-N IN TOMATO PETIOLE AT DIFFERENT STAGES OF GROWTH

Production system	NO3-N (ppm DM)					
	1994			1995		
	Bloom	One inch fruit	First colour	Bloom	One inch fruit	First colour
Convetional-4	14,275	9,225	775	7,920	7,653	240
Coventional-2	14,850	11,095	1,225	7,770	6,968	587
Low input	1,373	2,327	233	8,580	5,630	80
Organic	4,267	845	50	1,022	690	60

Source: Cavero, J., et al. 1997. The affect of nitrogen source and crop rotation on the growth and yield of processing tomatoes. The Netherlands, Kluwer Academic Publishers. Nutrient Cycling in Agroecosystems 42:271-282.

Other plant measurements and analysis not shown in this report confirmed the low levels of available soil N (Cavero et al, 1997).

During 1994 tomato plants under the low input and organic systems were also subject to reduced levels of soil available N. This was indicated by the low levels of nitrate N in the petioles (Table 6) as well as by other determinations.

Direct measurements of the (NO3-N + NH4-N) in soil samples taken at 0-30 cm and 30-90 cm, respectively, also confirmed the low levels of available N in organic soils (Cavero et al, 1997).

No reference was made on the effect of nitrogen sources and availability on tomato quality in the report by Cavero (1997) discussed above.

Transformation of Nitrogen in Manures and Composts - California

The study by Cavero et al. (1997) reviewed in the preceding section indicates that one of the reasons for the low N availability to the tomato crop grown under the organic system was the low proportion of organic N from turkey manure transformed into nitrate N during the growing season.

Given the importance of organic manures as supplemental sources of N for crops grown under organic systems, Hartz, Mitchel and Gianini (2000) conducted a two parts research to evaluate the transformation dynamics of nitrogen (N) and carbon (C) in manures, composted manures and composts from plant residues and municipal yard wastes. One part of the study was a bioassay where Fescue (*Festuca arundinacea* Shreb.) grown in pots under controlled conditions was used to measure the N released from the different amendments. The other part of the study consisted in direct laboratory measurements of the N and C mineralized from the amendments incubated under standard laboratory techniques at 25 ^{o}C.. As stated by the authors, " the primary objective of this study was to determine the N mineralization (transformation) dynamics of a range of manures and composts representative of those currently used as soil amendments in California vegetable production" (Hartz, Mitchel and Gianini, 2000).

A summary of selected characteristics of the organic amendments included in the study are described in Table 7.

Total and organic N concentrations in the amendments range from 4.7 to 1% and from 3.9 to 1%, respectively. Non composted manures have the highest N levels and the largest differences between the two types of N, probably due to a higher mineral N content. Composting results in a reduction of the difference between total and organic N, this effect

TABLE 7. RANGE OF SELECTED CHARACTERISTICS OF THE ORGANIC AMENDMENTS

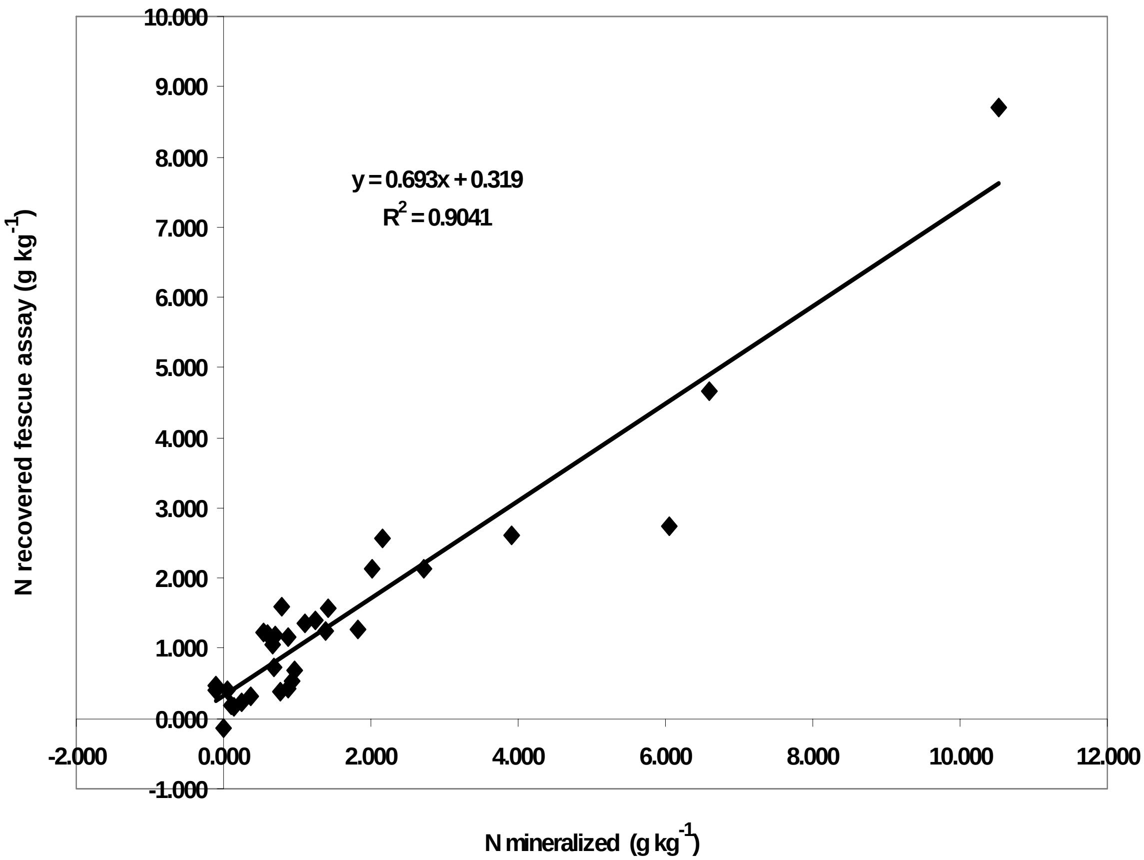
Amendments	Number of samples	Total N %	Organic N %	P %	K %	C/N ratio
Manure						
Poultry, pelletized	1	4.7	3.9	5.2	2.6	4.5
Poultry, dewatered	1	3.3	3.0	1.1	2.0	9.0
Poultry, aged	3	3.1 - 2.5	2.9 - 2.2	2.6 - 1.9	3.2 - 2.7	9.1 - 11.6
Feedlot, aged	2	2.4 - 2.0	2.0	1.3 - 1.1	1.7 - 1.4	12.4 - 12.5
Manure compost						
Poultry	7	3.8 - 1.3	3.6 - 1.3	1.4 - 2.9	0.5 - 3.0	5.7 - 10.2
Feedlot	6	2.2 - 1.9	2.2 - 1.8	1.2 - 0.6	3.2 - 2.0	8.8 - 11.4
Dairy	2	1.5 - 1.2	1.4 - 1.2	1.1 - 0.5	1.8 - 1.5	10.5 - 14.0
Residue compost						
Crop residue	1	1.2	1.2	0.2	1.4	9.3
Municip yard waste	8	1.7 - 1.0	1.7 - 1.0	0.4 - 0.2	1.4 - 0.6	9.3 - 15.5

Source: Hartz, T.K., Mitchell, J.P. & C. Giannini. 2000. Nitrogen and carbon mineralization dynamics of manures and composts. HortScience 35(2): 209-212.

being more apparent as the N content in the amendment decreases. No difference was observed below a nitrogen concentration of 1.4%. The C/N ratio shows a tendency to increase as the N content of the amendments decreases. The rates of N mineralization from organic amendments measured by the bioassay using Festuca (*Festuca arundinacea* Shreb) and by the laboratory incubation test presented a high correlation coefficient R = 0.95. The linear regression equation and the coefficient of determination R^2 are in Fig. 2.

The high correlation (R^2 = 0.904) between the mineralized N determined by the laboratory incubation method and by the plant bioassay indicates that the incubation method is an adequate analytical procedure to estimate the quantity of organic N that becomes available to plant from organic amendments. However, given the strong effect of temperature on microbial activity indicated early in this document, lower mineralization

FIGURE 2. CORRELATION OF N RECOVERED BY THE FESCUE *(Festuca arundinacea Shreb.)* BIOASSAY AND N MINERALIZED DURING INCUBATION OF ORGANIC AMENDMENTS



Source: Hartz, T.K., Mitchell, J.P. & C. Giannini. 2000. Nitrogen and carbon mineralization dynamics of manures and composts. HortScience 35(2): 209-212.

rates may be expected at lower temperatures prevailing during cold seasons in many agricultural regions over the world.

The values of total N uptake by fescue and organic N mineralized during the incubation, averaged for the different types of amendments, are in Table 8.

Absolute quantities of N mineralized range from 10.5 to less than 1.0 kg N mt^{-1} of amendment, ranging from 27.0 % to 1,3 % of the organic N present. The non composted animal manures have the highest quantities of organic N and the highest proportion of that N being mineralized, ranging from 39 to 20 kg N mt^{-1} and 27 to 11.4 %,

respectively. The residue composts, either from crops or municipal yard waste, have the lowest organic N content and mineralization rates, ranging from 15 to 12 kg mt^{-1} and 1.3 to –05%, respectively. This last figure corresponding to the crop residue compost represents a net mineral N immobilization by the amendment rather than a release of mineralized N. The manure composts represent intermediate figures between non composted manure and residue composts. Average figures for total N recovered in the fescue assay follow a similar pattern to that for the N mineralization laboratory test, and agree with the high correlation between the individual observations (Fig. 2).

TABLE 8. NITROGEN RECOVERED BY FESCUE *(Festuca arundinacea Shreb.)* FROM TOTAL N AND N MINERALIZED FROM ORGANIC N, RESPECTIVELY, IN SOIL AMENDMENTS. AVERAGE VALUES.

Amendments	Number of	Average total N	N recovered by Fescue [1]		Organic N [1]		Organic N mineralized [2]	
	samples	kg mt-1	kg mt-1	%	kg mt^{-1}	%	kg mt-1	%
Manure								
Poultry, pelletized	1	47	8.70	18.5	39	83	10.53	27.0
Poultry, dewatered	1	33	4.70	14.2	30	91	6.60	22.0
Poultry, aged	3	28	2.43	8.7	26	93	2.70	10.4
Feedlot, aged	2	22	1.71	7.8	20	91	2.27	11.4
Manure compost								
Poultry	7	24	1.47	6.1	23	96	1.83	8.0
Feedlot	6	21	1.01	4.8	20	95	0.74	3.7
Dairy	2	14	0.82	5.8	13	93	0.74	5.7
Residue compost								
Crop residue	1	12	0.40	3.3	12	100	-0.06	-0.5
Municip yard waste	8	15	0.27	1.8	15	100	0.19	1.3

[1]: kg N per mt of amendment. % of total N in amendments.
[2]: kg N per mt of amendment. % of Organic N in amendments.
Source: Hartz, T.K., Mitchell, J.P. & C. Giannini. 2000. Nitrogen and carbon mineralization dynamics of manures and composts. HortScience 35(2): 209-212.

From a practical farming point of view, the data in Table 8 indicates that to supply a crop with, for example, 50 kg of available N ha^{-1} when the soil temperature during daytime is at least 25 ^{o}C, the needed quantity of amendment would range from 5 to 20 mt ha^{-1} when using non composted manures, from 25 to 65 mt ha^{-1} when using composted manures, and over 200 mt ha^{-1} when using composted municipal yard wastes. The cost to the organic farmer associated to the transport of larger quantities of substance can not be ignored.

Transformation of Organic N from Animal Manures - United Kingdom.

A study was conducted in UK to (a) characterize the different manure N fractions, and, (b) determine the mineralization (transformation) rate of manure organic N through a bioassay using plants in a pot experiment. The information is required to predict both short- and long-term supply of plant available N to avoid accumulation in the soil and eventual losses by leaching and/or volatilization (Chadwick, D., John, F., Pain, B., Chambers, B. & J Williams, 2000). Fifty samples from different types of animal manures were included in the study. The average composition for the types of manures are in Table 9.

A pot experiment was conducted to estimate the mineralization rate of the organic N in a sub sample of 17 manures, applied at a target rate of 200 kg total N/ha. Perennial

TABLE 9. AVERAGE VALUES FOR SELECTED CHARACTERISTICS OF MANURE SAMPLES.

Manure type	Number of samples	Dry matter %	Fresh Weight basis		Dry Weight basis			C / N ratio
			Total N kg mt^{-1}	Organic N kg mt^{-1}	Total N kg mt^{-1}	Organic N kg mt^{-1}	Organic N % [1]	
Cattle slurry	12	11.1	4.1	2.9	37	26	71	9.63
Pig slurry	8	5.7	4.5	1.6	80	28	35	4.01
Cattle FYM	14	20.2	5.2	4.5	26	22	87	14.8
Pig FYM	6	22.7	8.6	6.1	38	27	71	9.84
Broiler litter	6	56.3	24.9	20.2	44	36	81	7.64
Layer manure	4	44.0	19.8	12.4	45	28	63	3.67

[1]: Organic N as % of total N, dry weight basis.
Source: Chadwick, D., John, F., Pain, B., Chamber, B. & J. Williams. 2000. Mineralization of organic nitrogen from animal manures. Fertilization for sustainable plant production and soil fertility.- 11th World Fertilizer Congress of CIEC.

ryegrass (*Lolium perenne* L.) was sown to the pots and kept for 200 days at 18 ^{o}C for 16 hour days and at 12 ^{o}C for 8 hour nights. A summary of results is in Table 10.

Layer manure and pig slurry present the highest levels of mineralization of the organic N in the amendments, 55% and 27.6%, respectively, measured by the N uptake of ryegrass grown under controlled conditions. Mineralization of the organic N for other substances

ranges from 21.3% for pig FYM to 12.2% for cattle slurry. The mineralization rate was found to be inversely related to the carbon to the nitrogen C / N ratio in the organic amendments.

TABLE 10. AVERAGE N CONTENT AND N UPTAKE BY RYEGRASS FROM ORGANIC N IN AMENDMENTS APPLIED TO A CONTROLLED POT EXPERIMENT.

Manure type	Number of samples	Dry matter %	Total N FW [1] kg mt^{-1}	Organic N FW		N uptake from org. N -- FW	
				kg mt^{-1}	% [2]	kg mt^{-1}	% [3]
Cattle slurry	3	11.08	4.12	2.92	70.87	0.36	12.20
Pig slurry	3	5.71	4.54	1.60	35.24	0.44	27.60
Cattle FYM	3	20.15	5.20	4.50	86.54	0.63	14.00
Pig FYM	4	22.66	8.58	6.08	70.86	1.30	21.30
Broiler litter	3	56.28	24.86	20.22	81.34	4.17	20.60
Layer manure	1	44.04	19.75	12.38	62.68	6.81	55.00

[1]: FW = based on fresh weight of amendment.
kg mt^{-1} = kg per mt of FW amendment.
[2]: Organic N as % of total N.
[3]: N uptke as % of organic N.
Source: Chadwick, D., John, F., Pain, B., Chamber, B. & J. Williams. 2000. Mineralization of organic nitrogen from animal manures. Fertilization for sustainable plant production and soil fertility.- 11th World Fertilizer Congress of CIEC.

According to the above results, except for layer manure and broiler litter, the application of even a moderate rate of available N to a crop will require the application substantial quantities of manures per hectare. The application of, i.e., 50 kg of available N ha^{-1} will require manure rates ranging from 38 tm/ha of pig FYM to 138 tm/ha of cattle slurry.

There is a general agreement of the results of this study (Chadwick, D., John, F., Pain, B., Chambers, B. & J Williams, 2000) with the study done by Hartz et all (2000). Except for a few substances, mineralization rates are around 20% or less of the organic nitrogen present in the amendment.

Corn Yield under Organic and other Management Systems in Crop Rotations - Minnesota

Two- and four-year rotation experiments were conducted at 2 sites, V1 and V2, in the Southwest Research and Outreach Center near Lamberton, Minnesota (Porter, P.M. et al, 2003). The objective was to compare four managements systems, i.e., high inputs (HI), low inputs (LI), organic inputs (OI), and zero inputs (ZI) under the two and four year rotation systems. The two-year rotation was a corn-soybean crop sequence. The four-year rotation was a corn-soybean-oat/alfalfa-alfalfa crop sequence. Each crop of each rotation was grown each year, with three replications. The yields of the two-year HI corn-soybean rotation were used as the basis of comparison because this cropping strategy most closely resembles the practices of the majority of farmers in the North Mid-West of the USA. A summary of most important results, corresponding to the HI, OI and ZI strategies are in Table 11.

TABLE 11. CORN YIELD RESULTS IN ROTATION EXPERIMENTS IN MINNESOTA

Crop rotation	Farming strategy	Average fertilizer rates			Average corn yield 1993-1999		Yield increase dY	Nitrogen efficiency
		N	P2O5	K2O				
	[1]	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	mt ha^{-1}	%	mt ha^{-1} [2]	dY/dN [3]
Site V1								
2 year	HI	146	70	44	8.96	100	4.57	31.3
4 year	OI	318	136	289	8.15	91	3.76	11.8
4 year	HI	69	69	43	8.60	96	4.21	61.0
4 year	ZI	0	0	0	4.39	49		
Site V2								
2 year	HI	143	24	22	8.72	100	1.05	7.3
4 year	OI	185	90	158	8.11	93	0.44	2.4
4 year	HI	62	29	17	8.72	100	1.05	16.9
4 year	ZI	0	0	0	7.67	88		

[1]: HI = high inputs; OI = organic inputs; ZI = Zero inputs.
[2]: dY = yield difference over the ZI yield.
[3]: dY/dN = Yield increase per unit of fertilizer N (kg kg^{-1})
Source: Porter, P.M., Huggins, D.R., Perillo, C.A., Quiring, S.R., & R.K. Crookston. 2003. Organic and other management strategies with two- and four-year crop rotations in Minnesota. Madison, Wisconsin, Agronomy Journal 95:233-244

In site V1, corn yield for the 2-yr high input (HI) strategy averaged 8.96 mt ha^{-1} over the 7 year period 1993-1999. Compared with this 2-yr HI strategy, the 4-yr organic (OI) strategy yielded 91%, the 4-yr HI strategy yielded 96% and the 4-yr zero input (ZI)

strategy yielded 49%. Low P soil levels may contribute to explain the low average corn yield in the ZI strategy.

In site V2, corn yield for the 2-yr high input (HI) strategy averaged 8.72 mt ha^{-1} over the 7 year period 1993-1999. Compared with the 2-yr HI strategy, the 4-yr organic (OI) strategy yielded 93%, the 4-yr HI strategy yielded the same and the 4-yr zero input (ZI) strategy yielded 88%. All yield responses over the ZI strategy in site V2 are rather low and the higher level of soil P, as compared to soil P level in site V1, may be a factor explaining the high yield for the 4-yr ZI strategy in site V2. The high average yield level for the ZI strategy may also explain the low efficiency for the added fertilizer nitrogen in site V2. However, nitrogen efficiency in the OI strategy is the lowest in both sites.

Synchronization of Organic N Transformation with Nitrogen Uptake by Crops.

When using only farm yard manure as a source of plant nutrients, it may be difficult to match the availability of nutrients in the soil with the demand of nutrients by the plant in a relatively short period of time. Mineralization (transformation into ammonium and nitrate) of organic nitrogen depends to a large extend on meteorological conditions and soil properties. And contrary to what can be done in conventional agriculture in organic farming it is not possible to apply readily available nitrogen from an external fertilizer source (Hebeisen et al, 2003), unless it is specifically permitted (USDA 2002). It should be stressed that what is important is not only the absolute content of available nitrogen in the soils but also the timing of the nitrogen availability with respect to the uptake rate by the crop being grown.

According to Hebeisen (2003) the availability of nutrients in the soil is today a factor that limits the productivity of organic farming. In some cases timing, environmental conditions or market constrains may limit the use of composting and cover cropping thus increasing the need for an application of readily available nitrogen. This is specially true in intensively farmed organic systems and on high value lands where cover cropping and composting offer significantly lower nitrogen inputs by weight (National Organic Standards Board Technical Advisory Panel Review. 2002; Small Planet Foods. 2002.).

Fate of N Applied as Natural Sodium Nitrate and Ammonium Sulfate to a Wheat Crop - Belgium.

In a field experiment conducted in Belgium by Riga, A. et al. (1988), the fate of split applied nitrogen from NSN and from Ammonium Sulfate was evaluated using an ^{15}N balance sheet and a micro-plot field technique. The specific objective was to evaluate the influence of the time of split application and type of N carrier on the fate of the amount of N applied at each split application. A total dressing of 100 kg N ha^{-1} was split into 35 kg ha^{-1} applied at end of tillering, 45 kg ha^{-1} at heading and 20 kg ha^{-1} at the beginning of flowering. In order to follow the fate of each N split application, ^{15}N-tagged Natural Sodium Nitrate ($Na^{15}NO_3$) and ^{15}N-tagged Ammonium Sulfate $(^{15}NH_4)_2SO_4$ was used. Percent recovery of fertilizer N by the crop is in Table 12.

The greater percentage of N recovered by the harvested whole plant as well as by the components grain and straw corresponded to the NSN carrier, whereas the Ammonium Sulfate carrier left the greater percentage of N in the soil. This result shows that available nitrogen in the soil applied as Natural Sodium Nitrate can be better synchronized with plant uptake than N supplied by Ammonium forms.

TABLE 12. EFFECT OF N FERTILIZER CARRIER ON THE RECOVERY BY WHEAT OF ^{15}N SPLIT APPLIED AT DIFFERENT STAGES OF DEVELOPMENT

N carrier	Plant component	N applied (kg ha^{-1}) Tillering end 35	Heading 45	Flower inic. 20
		N recovered (%)		
$NaNO_3$	Grain	34.2	51.5	55.7
	Straw	20.4	16.3	14.2
	Whole plant	54.6	67.8	69.85
	Soil	17.9	10.4	11.6
$(NH_4)_2SO_4$	Grain	32.2	48.4	52.5
	Straw	19.4	15.2	13.6
	Whole plant	51.6	63.6	66.1
	Soil	22.5	12.7	15.2

Source: Riga, A., Francois, E., Destain, J.P., Guiot, J. & R. Oger. 1988. Fertilizer nitrogen budget of $Na^{15}NO_3$ and $(^{15}NH_4)_2SO_4$ split-applied to winter wheat in microplots on a loam soil. Plant and Soil 106:201-208.

The use of NSN nitrogen is a complement to the organic sources of nitrogen in the organic farming system. Timely application of split doses of NSN can be synchronized with the crop N uptake, producing the best results in terms of yield, crop quality and protection of the environment.

Similar behavior of Nitrogen and Sulfur in organic farming

Plants take S from the soil as the sulfate ion that is dissolved in the soil solution. The original source of soil S was the metal sulfides in rocks, that by effect of weathering became oxidized to sulfate chemical form. Another source of S is the atmosphere. Burning coal and other S containing products releases sulfur dioxide to the air, that after being oxidized to the sulfate form is brought down to the soil by the rainfall. After being absorbed by plant roots and soil microorganisms the sulfate ion is reduced and incorporated into metabolic organic compounds much in the same way as the nitrate ion. From this stage on the S molecule follows a natural cycle similar to that of N, and the decomposing organic matter becomes a source not only of N but also of S for crops.

The sulfate ion is easily leached and very little or no sulfate^{-} derived from weathering of in soil parent materials is left in mature soil profiles. Also, because of growing human concern over air pollution, the release of S containing gases to the atmosphere is being restricted with the corresponding reduction of atmospheric supply of S to soils. As a consequence, and after de N deficiencies, sulfur deficiency is being reported as an important and frequent nutritional disorder in organic agriculture (Hagel , 2000; Haglund et al, 2000).

Organic amendments provide only a very limited amount of S with an average of 0.07 kg of S per kg of N. One metric ton of solid farmyard manure or one cubic meter of cow liquid manure brings about 0.3 to 0.4 kg S to the soil. However the release of plant available sulfate ions depends on the organic decomposition pathway that is similar to that of nitrogen (Revue Suisse dÁgriculture, 2001). To compensate the low S supply from organic substances and prevent or correct S deficiencies in organic farming, specific non-organic natural substances like Sulfate of Potash and Calcium Sulfate can be used (Lampkin, N., 2002). By the same rationale, and to correct the present asymmetric situation, Chilean Natural Nitrate should be allow to be used by all organic farmers to compensate the insufficient N supply from organic amendments.

Role of Natural Sodium Nitrate in organic farming.

Natural Sodium Nitrate is a substance that complement organic nitrogen sources by providing controlled quantities of nitrate nitrogen that can be synchronized with crop demand and that is available irrespective of the weather conditions or soils pH. It also supplies part of the need of microelements important for crop and human plus an amount of sodium that contributes to neutralize the soil acidity that accumulates due to the decomposition of organic N and S sources. As it is indicated elsewhere in this document, this natural source of nitrate nitrogen, extracted from nature using no chemical treatments, complies with the principles of organic farming and because of that it is currently accepted and used by important groups of organic farmers.

5.1 (a)-2. The ingredient will be of plant, animal, microbial or mineral origin and may undergo the following processes: physical (e.g. mechanical, thermal), enzymatic, microbial (e.g., composting, fermentation) ; only when the above processes have been exhausted, chemical processes may be considered and only for the extraction of carriers and binders .

<u>Location of the Natural Sodium Nitrate Deposits</u>

Natural Sodium Nitrate is mined from natural deposits of Caliche.. The Caliche nitrate ore is found in the Chile´s Atacama Desert, in discontinuous strips on the eastern pacific coastal range between the latitudes of 19° and 26° (Fig 4). Most of the deposits are located at altitudes of less than 2000 m although some are higher. The nitrate fields occur in areas that are typically low in relief. In the Tarapaca district - which was the chief source of nitrate prior to 1870 - are found the richest nitrate ores. Current mining activity is centered in the Tocopilla district in the Antofagasta province. Variable grade nitrate deposits containing 1 to 7% NSN are scattered on all the Atacama Desert.

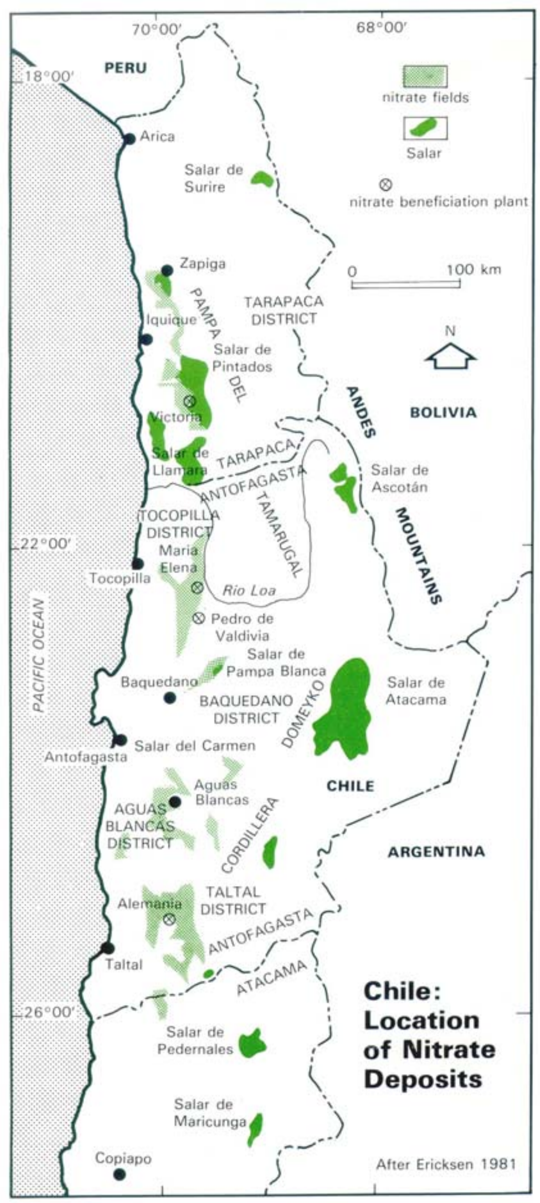


FIG. 4. Location of Nitrate Deposits

<u>The Atacama Desert.</u>

In a recent paper published in Science magazine by Navarro-Gonzalez, Rainey & Others (2003) a NASA´s team of scientist reported that they discovered an area of Earth that is shockingly similar to the Mars surface, the Atacama Desert. NASA Viking mission to Mars in the 1970s showed the Martian soil to be lifeless and depleted of organic materials, the chemical precursors necessary for life. During 2002, in the driest part of the Desert the research team conducted microbe-hunting experiments similar to Viking´s, and no evidence of life was found.

The Atacama is a temperate desert that extends across 1000 km with monthly mean air temperatures between 16 to 14 ^{o}C and is remarkably uniform throughout the year (±3 ^{o}C). The extreme aridity is due to the combined effects of a high pressure system located on the western Pacific Ocean, the drying effect of the cold north-flowing Humboldt ocean current, the oceanic cloud barrier effect of the Cordillera de la Costa, and the rain shadow effect of the Cordillera de Los Andes intercepting precipitation from the Inter-tropical Convergence (Navarro-Gonzalez, Rainey & Others, 2003). Geological and soil mineralogical evidence suggest that the extreme arid conditions have persisted in the southern Atacama for 10-15 Myr making it one of the oldest, if not the oldest desert on Earth. The age and aridity of the Atacama Desert are probably directly responsible for the large nitrate accumulations that are present there. The nitrates are likely to be of atmospheric origin (Ericksen, 1983).

<u>Description and Origin of the Natural Sodium Nitrate Deposits</u>

Caliche deposits occur in rocks and unconsolidated sediments without showing any systematic variation in mineral content. Most widespread are the regolith conglomerates of insoluble and barren material cemented by soluble salts; predominantly sulfates, nitrates and chlorides of Na, K and Mg. Apart from the Natural Sodium Nitrate the Caliche does have small quantities of borates, chromates, and iodates as well as somewhere around 30 trace elements including iodine, copper, zinc, boron and molybdenum. There are several theories on the origin and formation of the natural nitrate deposits. Their discussion is beyond the scope of this document and the interested reader is referred to Ericksen, G.E. (1981) for a presentation of his own investigations and a well documented discussion of the subject. Nevertheless, it should be noted that the single most important factor in the accumulation of saline materials in the Atacama Desert has been the extreme aridity of the region which has existed since 10 - 15 million years. But although the climate of the Atacama Desert has been extremely arid throughout late Tertiary and Quaternary time, there have been intervals of climatic change when increasing rainfall greatly modified or destroyed preexisting nitrate deposits. According to Ericksen G.E. (1981), if the nitrate deposits were formed during the past 10 – 15 million years and if they have a complex history of repeated deposition and destruction, a rate of deposition whereby the nitrate might accumulate in 200.000 years is reasonable. That would be an estimated theoretical

period of time for the formation of the present day deposits, with the added implication that no rainfall with nitrate leaching capacity has occurred during that period.

Nitrate rich soils occur locally in other deserts areas of the world but are nowhere as widespread and with concentrations as those found in the Atacama Desert.

Caliche Mining and Extraction of Natural Sodium Nitrate

The extraction of NSN is based on a dissolution – crystallization system not including chemical processes or ionic exchange.

The Caliche is grounded to a size of 1.0 centimeter and between 75 and 80% of the tonnage reduced to this size is deposited in large 10,000 m^3 capacity lixiviating vats. The fine residue from the grounding process is sent to a different lixiviation system, where iodine is recuperated.

Warm 48 ^{o}C "weak mother solutions" are circulated through the Caliche particles in the vats, until the solution is saturated in NSN becoming a "strong mother solution". The strong solution is cooled to 12°C in order to crystallize and precipitate the dissolved NSN . After recovering dissolved iodine at the iodine plant, the resulting "weak mother solution" is sent back to the lixiviation vats to a new cycle in the close lixiviation-precipitation circuit. In this close lixiviation circuit water may be lost only by .evaporation, in particular when it is sent to the Solar Evaporation System, discussed in the next section.

New fresh water is not used in the lixiviation cycle, except when is needed to displace the "strong mother solution" from the refuse. Due to limitations in the quantity of water used to wash the refuse and since this limited volume is not fully efficient in displacing all the "strong solution" the retrieval of the sodium nitrate from the Caliche is only about 75%.

The crystallized sodium nitrate is centrifuged and granulated, being ready to be used as a source of natural nitrate nitrogen in crop production.

Solar Evaporation System - Use of Renewable Energy in the extraction of Natural Sodium Nitrate

Through the cooling and centrifugation process, only NNC and iodine can be recuperated from the Caliche ore. However, the Solar Evaporation System (SES) permits the retrieval of additional NNC and other salts from the “weak mother solution” before it is recycled to the lixiviation vats. The SES is also used to concentrate solutions produced by “heap leaching” or lixiviation of old refuse piles of Caliche ore, that were processed many years ago to extract NNC using less efficient processes.

The operation of the SES begins by adding additional water to the refuse wash in the lixiviation vats. The water not only displaces additional NNC that otherwise goes with the refuse, but it also dissolves potassium double salts, borates, iodine, sulfates, magnesium salts and others, which are only partly soluble in the “strong mother solution”. After passing through the normal cooling-cristalization stage the new weak solutions are not sent back to the lixiviation vats to start a new cycle, but instead they are pumped to the Solar Evaporation System to be concentrated.

The Solar Evaporation System consist of a series of interconnected ponds where the solution moves from a first pond having the initial or lowest salt concentration up to the last pond with the highest salt concentration that can be attained through solar evaporation. After reaching the predetermined optimum salt concentration, the NSN is recovered from the solutions by cooling and crystallization , and the final weak solution is sent to the vats to start a new lixiviation cycle of Caliche ore.

There are two Solar Evaporation Plants, Coya Sur and Pampa Blanca, with 550,000 m^2 and 544,000 m^2 of pond evaporating surface, respectively. The average daily evaporation rate for the whole year at each Plant is 4.5 L m^{-2} and 3.5 L m^{-2} , respectively, this being another consequence of the permanent dry conditions in the Atacama Desert. The total volume of water evaporated from the solar ponds is over 1.6 million cubic meters per year and the corresponding solar energy captured is 3.6 million Giga Joules (GJ). This quantity of energy correspond to 25 GJ per metric ton of nitrogen (N) extracted from the Caliche. The average energy used to produce a metric ton of N in chemical fertilizers is around 40 GJ (EFMA, ca 2000). Total energy used to produce a metric ton of Natural Sodium Nitrate is close to this average. However, only 19 GJ are non-renewable energy or 43% whereas the remaining 57% is solar energy The Natural Nitrate is not only a natural

substance but the largest proportion of the energy used in the extraction process is renewable solar energy.

5.1 (a)-3. Their use does not have a harmful impact on the balance of the soil ecosystem or the physical characteristics of the soil, or water and air quality

Nitrate nitrogen Dynamics in Soils.

Any kind of organic nitrogen, i.e., from crop residues, legume cover crops, compost, manure, etc., is naturally transformed to mineral N in the soil, most of it to nitrate nitrogen, in order to be up taken by plant roots. The transformation is performed by soil microorganism and it is affected mainly by soil temperature, soil moisture, oxygen availability, soil pH, type of clay and carbon to nitrogen (C/N) relationship in the organic substances. Hence nitrate nitrogen is a natural substance in soils and it is the main source of nitrogen for growing crops.

As it was indicated elsewhere in this document, under open field conditions it is not always possible to maintain at optimum levels all natural factors that control the activity of soil microorganisms. As a direct consequence, the rate of transformation of soil organic nitrogen is not always synchronized with the rate of nitrogen uptake by crops. Even if the most important agronomic and soil factors are kept at adequate levels, during cold seasons the transformation rate may not be sufficient to supply the mineral nitrogen needed by a growing crop to produce adequate yield and quality levels. But during warm seasons, the transformation rate will be high and special cropping practices may be necessary to prevent leaching of nitrate nitrogen produced in excess of crop demand.

Winter and early spring are the seasons during which most nitrate leaching occurs in humid temperate and Mediterranean climates (Brady & Weil. 1999. p. 505) and available nitrate nitrogen cannot be stored as such in the soil profile during late summer and autumn to be used by winter and spring crops. Excessive nitrate nitrogen produced during the warm season can be stored in the soil only if it is reconverted into organic nitrogen by soil microorganisms and by crops specifically cultivated for that purpose. This nitrogen will be mineralized again only at the start of the next warm season.

Application of nitrate nitrogen from NSN during low temperature seasons is just a complement to the low levels of nitrate being produced at that time by soil microorganisms because of the seasonal unfavorable conditions. The NSN resulted from ecological processes at ancient ages and it use in organic farming is fully analogous to the use of fossil bird guano, also produced in earlier ages, as a phosphorous supplement or the use of mineral calcium, potassium or magnesium inorganic compounds produced by natural reactions in ancient times.

Dynamics of Sodium in Soils.

The positive ions calcium, magnesium, potassium and sodium are normal components of the soil solution. However, they are also held on the surface of soil colloids by electrostatic negative charges. This system constitute the soil Cation Exchange Capacity (CEC). An important characteristic of the CEC is that the different elements are not held with equal tightness. The order of cation adsorption strength, or *Lyotropic Series*, is calcium > magnesium > potassium > sodium (Tisdale, S.L. et al. 1993. p. 89-90). Sodium is held with the least strength being the easiest positive ion to be leached by rainfall or irrigation water. Hence the normal soil leaching process prevents sodium accumulation in normal soil profiles. The only exception are dry soils or soils with poor internal drainage, where no sodium salt should be used.

It is an historical fact that Natural Sodium Nitrate has been widely used in crop production under different soil and climatic conditions in many countries since around 1860 and continue being used today with no reported soil damage. Wheat, maize, cotton, tobacco, sugar beet, vegetables and fruits are just a few of the most common crops successfully fertilized with NSN. In Japan, the sugar beet crop has been fertilized with NSN for more than 80 years and the application continue today with no sign of negative effects (Mitsubishi, 2001). As reported by Cooke (1982, p. 158) the continuous application of sodium salts including NSN for almost a 100 years in the Rothamsted Classical Experiments in the United Kingdom has show no sign of damage to the soil. Results from the Rothamsted Classical Experiments that show not only the lack of damage but also the yield benefits from continuous use of NSN - compared with other well known ammonium based nitrogen fertilizer - are presented following the next section.

Sodium in Agriculture.

Proper use of sodium in agriculture, with restrictions in poorly drained and dry-land soils, provides benefits not only to farm soils but also to halophytic crops and farm animals. A complete discussion of this subject is beyond the scope of this document and interested readers are referred to Lunt (1966), Marschner (2002)) and Phillips & Chiy (1995) for updated presentations on the subject.

Effect of Continuous use of Ammonium Sulfate and Natural Sodium Nitrate for over 80 Years on Wheat Grain and Straw Yield.

This comparison of Ammonium Sulfate and NSN is part of the Broadbalk Experiment conducted at Rothamsted, U.K., since 1844. The comparison spans the years 1885 – 1967, and the fertilizers were applied at two rates, 48 and 96 kg N ha^{-1}, first over continuous wheat (1885-1925) and then during six-year fallow cycles. Other nutrients were supplied to all plots to prevent deficiencies. A summary of main results are in Table 13. The advantage for NSN was greater during the first 41 years when wheat was grown continuously, specially for the smaller N rate with positive differences of 376 kg grain ha^{-1} (26%) and 916 kg straw ha^{-1} (40%).

TABLE 13. COMPARISON OF NATURAL SODIUM NITRATE AND AMMONIUM SULPHATE FOR OVER 80 YEARS IN THE ROTHAMSTED EXPERIMENTAL STATION, UNITED KINGDOM.

Crop rotation	Time period	Fertilizer N Rate	Wheat yield		Straw yield	
			Ammonium sulphate	Nat. Sodium nitrate	Ammonium sulphate	Nat. Sodium nitrate
		kg N ha^{-1}	kg grain ha^{-1}	kg grain ha^{-1}	kg straw ha^{-1}	kg straw ha^{-1}
Continuous wheat	1885-1925	0	904		1,268	
		48	1,456	1,832	2,309	3,225
		96	2,108	2,221	3,803	4,418
		Mean N effect	1,782	2,027	2,460	2,548
Six fallow cycles	1935-1964	0	1,606		2,748	
		48	1,995	2,134	3,577	3,828
		96	2,472	2,711	4,706	5,083
		Mean N effect	2,234	2,422	4,142	4,455
Whole period	1885-1967	0	1,142		1,795	
		48	1,606	1,870	2,761	3,414
		96	2,184	2,359	4,142	4,606
		Mean N effect	1,895	2,115	3,451	4,010
		Yield difference		220		558
		Yield difference %		12		16

Source: Garner, H.V. & G.V. Dyke. 1968. The Broadbalk yields. Harpenden, UK, Rothamsted Experimental Station. Report for 1968, Part 2 pp. 34-35

Fallowing increased the average yield of grain and straw but the superiority of the NSN remained in the second period. Averaging the result for both N rates over the whole period of 83 years, NSN produced 220 kg more grain and 558 kg more straw per ha than Ammonium Nitrate, representing yield increases of 12% and 16%, respectively.

Effect of Organic and Inorganic Sources of Nitrogen on Earthworms Population in Soils

Earthworms play a unique role in building soil structure, by helping the aggregation of soil particle and the formation of a crumb structure. By processing soil and organic residues through its gut, clay and organic matter are intimately mixed and coated with organic stabilizing gums and lime secreted from a special gland within the digestive tract. The result, the worm cast, consist of the type and size of water-stable soil aggregate needed to provide adequate water holding capacity, aeration and nutrient reserves for plant growth (Lampkin, N., 2002). Earthworms cannot tolerate soil acidity, the use of ammonium sulfate, certain herbicides and fungicides, rotary cultivators and the failure to retain sufficient organic residues in the soil.

There is still a great deal to be learnt about the interactions between type and quantity of fertilizer use, crop grown, cultivation practice and earthworm activity. Research by Edwards and Lofty (1982) at Rothamsted, and other research papers quoted by Lampkin, N., (2002), found that straw removal and certain cultivation techniques could have an adverse effect on earthworms and other soil organisms. They also found that the species of earthworms were more numerous in plots treated with organic fertilizers than in untreated plots. There was a strong positive correlation between the rate of inorganic N applied and populations of earthworms, probably because of the increased production of roots and residues, although organic fertilizers increased earthworm population much more than inorganic N sources. However, plots receiving both organic and inorganic N had the largest population of earthworms.

Edwards and Lofty (1982) consider that the harmful effect of fertilizers reported elsewhere may be due to increased soil acidity. According to the above results, the use of organic N sources combined with Natural Sodium Nitrate should provide a good soil environment for the development of earthworms, in particular because the alkaline reaction of the Natural Sodium Nitrate will help to neutralize the acidification resulting from the decomposition of organic substance and release of nitrate nitrogen..

5.1 (a)-4. Their use may be restricted to specific conditions, specific regions or specific commodities.

General Considerations

The use of Natural Sodium Nitrate may be restricted in saline and sodic soils, as well as in rain fed agriculture with limited rainfall and no other source of water, in semi arid and arid environment with no irrigation, in soils with poor drainage and in general under conditions that sodium may tend to accumulate in the soil profile. In the USA, the use of NSN in organic farming is restricted to 20% of the N needed by the crop being grown.

Saline and Sodic Soils

A special case consist the saline and sodic soils that exist in a few specific regions of the world. Saline soils have an excess of soluble salts. The electrical conductivity (EC) of the saturated extract of saline soils is 4 dS m^{-1} (decisiemens per meter) or higher. Some saline soils are also sodic because they have an excess of sodium. Sodic soils generally have pH higher than 8.5 . A saline soils is classified as sodic if the exchangeable sodium percentage (ESP), i.e., the sodium saturation percentage of the Cation Exchange Capacity, is 15% or higher. Another criterion to define a sodic soil is that the value of the sodium adsorption ratio (SAR) is 13 or higher (Brady & Weil, 1999. p. 385-389)

The chemical determinations EC, EPS and SAR used to define saline and sodic soils are standard analytical procedures and can be requested in most soil test laboratories (Westerman, 1990) They can be used to decide on the proper use of Natural Sodium Nitrate . However, there are two special considerations valid for soils subject to organic farming systems. The decomposition of applied organic sources and the release of nitrate N produce soil acidification. In this respect the addition of Chilean Natural Nitrate is nor only a complement of ready available N but also an agent to neutralize that acidification resulting from the mineralization of organic N sources. Also the decomposed organic substances represent an additional source of negative charges that increase the soil CEC, thus increasing the soil ability to properly handle the limited amounts of sodium contained in the Natural Sodium Nitrate .

References

Blankenau, Klaus. 2000. Einfluss der Stickstoffimmobilisation auf die Verfugbarkeit von Dungerstckstoff fur Getreide. Dissertation Universitat Hannover, Institute fur Pflanzenernahrung. Verlag Grauer, Beuren, Stuttgart, Germany. 151 p

Brady, N.C. & R.R. Weil. 1999. The nature and properties of soils. 12th edition. New Jersey, USA, Prentice-Hall, Inc. 881 p.

Chadwick, D.R., John, F., Pain, B.F., Chambers, B., & J. Williams. 2000. Mineralization of organic nitrogen from animal manures. 11th World Fertilizer Congress, Fertilization for sustainable plant production and soil fertility.

Chadwick, D.R., John, F., Pain, B.F., Chambers, B., & J. Williams. 2000. Plant uptake of nitrogen from the organic nitrogen fraction of animal manures: a laboratory experiment. Journal of Agricultural Science 134: 159-168.

Cooke, G.W. 1982. Fertilizing for maximum yield. 3rd ed. London, UK, Granada Publishing Limited. 465 p.

Doran,J.W. & M.S. Smith. 1987. Organic matter management and utilization of soil and fertilizer nutrients. In Follet, R.F. & others. Soil fertility and organic matter as critical components of production systems. Madison, WI, USA, SSSA Special Publication No. 19. p. 53-72.

Edwards, C & J.R. Lofty. 1982. Nitrogenous fertilizers and earthworm populations in Agricultural soils. Soil Biology and Bichemistry 14: 515-521.

EFMA. ca 2000. Harvesting Energy with fertilizaers. European Fertilizer Manufacturers Associatión . Av. E. va. Nieuwenhuyse 4, B-1116 Brussels, Belgium.

Ericksen, George E. 1981. Geology and origin of the Chilean nitrate deposits. US Department of Interior, Geological Survey Professional Paper 1188. 37 p.

Ericksen, George E. 1983. American Scientist 71: 366

Garner, H.V. & G.V. Dyke. 1968. The Broadbalk yields. Harpenden, Hert, UK. Rothamted Experimental Station, Report for 1968, Part 2, p. 34-35.

Hagel, I. 2000. Auswirkungen einer Schwefeldungung auf Ertrag und Qualitat von Weizen schwefelmangelgefahrdeter landbouw. Landbouwuniversiteit Wageningen.

Haglund, S, Ebbesvik, M & S. Hansen. 2000. Is ley production in organic farming limited by su-optimum sulphur supply?. Proc 13th IFOAM Scientific Conference, Basel, Switzerland. P.31.

Hartz, T.K., Mitchell, J.P & C. Gianini. 2000. Nitrogen and carbon mineralization dynamics of manures and composts. HortScience, Vol. 35(2):209-212.

Havlin, J.L, Beaton, J.D., Tisdale, S.L. & W.L. Nelson. 1999. Soil fertility and fertilizers. An introduction to nutrient management. 6th ed. New Jersey, USA, Prentice-Hall Inc. 499 p.

Hebeisen, T., Ballmer, T., Torche, J.M. & Werner Reust. 2003. Etude varietale pour la culture biologique des pommes de terre: le point de la situation. In: Station federale de recherches en agroecologie et agriculture, Zurich-Reckenholz, Swiss Les Cahiers de la FAL 45 : 30-36.

Kuo, S., Sainju, U.M., & E.J. Jellum. 1997. Winter cover cropping influence on nitrogen In soils. Madison, Wisconsin, Soil Science Soc. of Am. Journal 61:1392-1399.

Lampkin, Nicolas. 2002. Organic Farming. 104 Valley Road, Ipswich IP1 4PA, United Kingdom, Old Pond Publishing. 747 p.

Lunt, Owen Raynal. 1966. Sodium. In Chapman, H.D. ed. Diagnostic criteria for plants and soils. University of California, Division of Agr. Sciences. p. 409-432.

Marschner, Horst. 2002. Mineral nutrition of higher plants. 2nd ed. London, UK, Academic Press Limited. 889 p.

McGill, W.B. & R.J.K. Myers. 1987. Control on dynamics of soil and fertilizer nitrogen. In: Follett, R.F., Stewart, J.W.B. & C.V. Cole. Eds. Soil fertility and organic matter as critical components of production systems. Madison, Wisconsin, USA, Soil Sci. Soc. of Am. Inc. & Am. Soc. of Agronomy. p. 73-99.

Mengel, K. & E.A. Kirby. 1987. Principles of plant nutrition. Bern, Switzerland, International Potash Institute. 687 p.

Menzi, M. & M. Anders. 2003. Essais varietaux de cereals dans les condicions de lagriculture biologique. Zurich-Rekenholtz, Swiss, Station Federal de Recherches en Agroecologie. Les Cahiers de la FAL 45: 24-29.

Mitsubishi Co. 2001. History of Chilean Nitrate in Japan imported by Hokuren. Personal communication.

Navarro-Gonzalez, R., Rainey, F.A., & Others. 2003. Mars-like soils in the Atacama Desert, Chile, and the dry limit of microbial life. Science Vol. 302 No. 5617 : 1018-1021.

National Organic Standards Board Technical Advisory Panel Review. 2002. Chilean Nitrate for general use as an adjuvant in crop production. USA, University of California Sustainable Agriculture Research and Education Program, USDA National Organic Program. 11 p.

Phillips, C.J.C. & P.C. Chiy. 1995. Sodium in agriculture. United Kingdom, Chalcombe Publications. 217 p.

Pinilla, H. 1993. Efecto del uso sucesivo de nitrógeno nítrico y amoniacal en la Acidificación de suelos trumaos. Frontera Agrícola 1(1): 18-22.

Porter, P.M., Huggins, D.R., Perillo, C.A., Quiring, S.R., & R.K. Crookston. 2003. Organic and other management strategies with two- and four-year crop rotations in Minnesota. Madison, Wisconsin, Agronomy Journal 95:233-244.

Power, J.F. & J.W. Doran. 1988. Role of crop residue management in nitrogen cycling and use. p. 101-113. In J.W. Doran et al., (ed.) Cropping strategies for efficient use of water and nitrogen. ASA Spec. Publ. 51. ASA, CSSA, and SSSA, Madison, WI.

Revue Suisse d'Agriculture. 2001. Donnees de base pour la fumure des grandes Cultures et des herbages. Suisse, Station federale de recherches agronomiques de Changins et Federation des societes d'agriculture de la Suisse Romande. Vol 33, Nr. 3.

Riga, A., Francois, E., Destain, J.P., Guiot, J. & R. Oger. 1988. Fertilizer nitrogen budget of $Na^{15}NO_3$ and $(^{15}NH_4)_2SO_4$ split-applied to winter wheat in micro-plots on a loam soil. Plant and Soil 106: 201-208.

Schnug, E. 1991. Das Raps-Handbuch. 5. Aufl. Bad-Homburg: ELANCO, pp. 72-87.

Small Planet Foods. 2002. Personal communication. National Organic Standards Board Members. USDA, Washington, DC. 4p.

Tisdale, S.L., Nelson, W.L., Beaton, J.D. 1985. Soil fertility and fertilizers. 4th ed. New York, USA, Macmillan Publishing Company. 754 p. .

Tisdale, S.L., Nelson, W.L., Beaton, J.D. & J.L. Havlin. 1993. Soil fertility and fertilizers. 5th ed. New York, USA, Macmillan Publishing Company. 634 p.

Utomo, M., Frye, W.W., & R.L. Blevins. 1990. Sustaining soil nitrogen for corn using hairy vetch cover crop. Madison, Wisconsin, Agronomy Journal 82:979-983.

Westerman, R.L. editor. 1990. Soil testing and plant analysis. 3rd ed. Madison, Wisconsin, USA., Soil Science Society of America, Inc. 784 p.