GUIDE OF GOOD AGRICULTURAL PRACTICES AGAINST NITRATE POLLUTION

PROJECT LIFE + "EUTROMED"

Project selected and funded by the European Union with the objective of improving the quality of our water and agricultural soil.

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Prevención de la eutrofización por nitrógeno agrícola

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GUIDE OF GOOD

AGRICULTURAL PRACTICES

AGAINST NITRATE POLLUTION

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INTRODUCTION

I. INTRODUCTION.

The following Code of Good Practices has been carried out in the frame of the project LIFE 10 ENV/ES/511 EUTROMED, developed by the County Council of Granada together with the institute of Water (University of Granada) and the Companies Bonterra Ibérica and Paisajes Del Sur. The general objective of this project is to improve the quality of water and agricultural soils against nitrogen pollution from agricultural sources.

Fertilizers represent one of the main inputs of agricultural production, so the efficiency in their utilization constitutes an important source for savings and reduction of environmental impacts. Thus, an excessive fertilization, not adjusted to the real requirements for cultivation, may cause problems due to nitrate lixiviation, water eutrophication and greenhouse gas emissions, as well as an unnecessary expense that does not have repercussion on production as an equivalent increase. In the same way, an insufficient fertilization causes not only a reduction of the crop performance, but also a decay of soil fertility.

This guide answers to the community demands collected in the Council Directive 91/676/CEE, of December 12th 1991, regarding water protection against nitrate pollution from agricultural sources, as well as the Royal Decree 261/1996 of February 16th about water protection against nitrate pollution from agricultural sources.

The diversity of climatic, pedological conditions as well as cultural practices present in the Andalucía agriculture have become an inconvenience when trying to establish - in general, a series of rules for farmers, regarding organic and mineral fertilization of soils.

Because the olive grove is the target zone of EUTROMED Project, this guide will analyze in detail the particular situation of this type of exploitation, providing a general and specific vision for the problem of water pollution by nitrates, and describing the products or actions that constitute potential sources of contamination.

Image 1. Water streams near to agricultural zones.

The Code of Good Practices does not have a mandatory status. It is more a compilation of agricultural practices to be carried out voluntarily by farmers -the principal receivers of this Guide of Good Practices- due to their main role in agricultural production. Nevertheless, once the administration has designated the vulnerable zones to nitrate pollution, and determined action programs, these preventive measures shall become of mandatory character.

Therefore, this work will be useful, as framework for the development of an environmentally-minded agriculture, articulated with a rational use of nitrogen compounds.

LEGISLATION

2. LEGISLATION CONCERNING THE PROTECTION OF WATER AGAINST NITRATE POLLUTION.

2.1. Compilation of Policies.

a) EU Legislation.

- DIRECTIVE 91/676/CEE, of 12 December 1991, concerning the protection of waters against pollution caused by nitrates from agricultural sources.

- DIRECTIVE 78/659/CEE, of 18 July 1978, on the quality of fresh waters needing protection or improvement in order to support fish life. The directive will be derogated after 12/22/2013.

- DIRECTIVE 80/68/CEE, of 17 December 1979, concerning the protection of groundwater against pollution caused by certain dangerous substances. The directive will be derogated after 12/22/2013.

b) National Legislation.

- Royal Decree 261/1996, of 16 February 1996, concerning the protection of water against nitrate pollution of agricultural sources.

- Order of 28 May 1998, concerning fertilizers and related products.

c) Legislation of the Andalucía Autonomous Community.

- Resolution of 12 December 1997, of the General Secretary of Agricultural Production, to order the publication of the Code of Good Practices of Andalucía for the protection of water against nitrate pollution from agricultural sources, published in BOJA number 2, January 8th 1998.

- Decree 36/2008, of February 5th, to designate vulnerable zones and to establish measures against nitrate pollution from agricultural sources.

- Order of November 18th 2008, concerning the approval of the Action Program for the zones vulnerable to nitrate pollution from agricultural sources designated in Andalucía.

- Amendments of the Order of November 18th 2008, concerning the approval of the Action Program for the zones vulnerable to nitrate pollution from agricultural sources designated in Andalucía (BOJA number 4, 1/8/2009).

2.2. Objectives of the Policy.

The Council Directive 91/676/CEE, of 12 December de 1991, concerning the protection of water against nitrate pollution from agricultural sources, was adopted as a consequence of the awareness raised about the environmentally risky overutilization of fertilizers, and the dumping of waste from livestock sources and the awareness that the main cause of pollution by diffuse sources affecting communitarian waters are nitrates from agricultural source.

The Directive holds as fundamental objectives to establish necessary measures to prevent and correct the pollution of continental and coastal water, caused by nitrates of agricultural source, and to take preventive measures against new pollution agents from the same source.

The instructions contained in the regulation are focused on reaching a progressive reduction of nitrate pollution, and, on the other hand, meant to keep preventive actions in the face of potential new sources of pollution in the future.
This Directive is transposed to the Spanish legal system by Royal Decree 261/1996, of February 16th, establishing the prioritary objectives of reducing pollution caused or provoked by nitrates from agricultural sources, and to act mandatorily against new pollution agents from the same source.

The Autonomous Government of Andalucía, through Resolution of December 12th 1997 of the General Secretary of Agricultural Production, has developed the Code of Good Practices of Andalucía, compiling a series of updates concerning common agricultural practices, focusing on the mitigation of environmental impact of nitrogen fertilizers in the framework of a modern, sustainable and modern agriculture.

FERTILIZATION USING NITROGEN

3. FERTILIZATION USING NITROGEN.

3.1. Importance of Nitrogen Fertilization.

Nitrogen has been determinant in the increase of agricultural production during the last fifty years. Ammonium synthesis using atmospheric nitrogen and its subsequent transformation in nitrogen fertilizers has allowed, together with the utilization of other production means, the increasing of performance for most of crops to their current levels.

Several studies have shown that a third part of the increase of world production of cereal during the seventies and eighties is an outcome of the increment in the use of fertilizers. **However, when nitrogen is not used properly, it can bring negative effects on the environment**, among them water pollution caused by nitrate lixiviation. This is usually associated with **inefficient utilization guidelines of fertilizers by the farmers and/or ranchers.**

The farmers, with a good management of labor and keeping a good soil structure and a proper content of organic material, can influence positively in the reduction of pollution.

Image 2. Visual analysis of nutritional status of the soil.

In this sense, **a good balance of nutrients, a proper fertilization planning and some adequate practices are essential for the protection of water against nutrient contamination.**

To optimize the calculation of mineral fertilization for the whole exploitation set, the requirements of the crop must be taken into account.

To accomplish this goal, there are a number of software programs for the calculation of fertilization, taking into account aspects such as the physicochemical analysis of the soil, the mean pluviometry during crop development, mean and expected production, previous and posterior crops and the organic improvements applied, resulting in optimal units for application, the timing and the type of fertilizer.

*** to remember**

1) Applying necessary nutrients is the key to a good crop, but when used in excess, besides losing money, they can cause pollution of groundwater and surface water bodies.

2) Whenever possible, fertilizers must be applied on the basis of available nutrients, calculated over foliar analysis, soil analysis and irrigation.

3.2. Main nitrogen products.

Fertilizers with exclusively organic nitrogen (N).

Organic fertilizers contain N in protein form. Because the protein structure is more or less complicated, the availability of N for plant nutrition is approximately differentiated in time, from a few weeks through a few months. Such availability goes through a series of transformation of Nitrogen: starting as aminoacid, becoming successively ammonia nitrogen and finally becoming nitric nitrogen. Thereby, fertilizers have their best application in the basal fertilizing and long-cycle crops.

Fertilizers with organic and mineral nitrogen (N) (organomineral fertilizer).

Products working as triggers of Nitrogen activation in a chronological sequence. Also, these products enhance the combination of organic substances of high quality per nutrient, improving their availability to the plant.

Fertilizers with slow release nitrogen (N).

Fertilizers of delayed action that release Nitrogen slowly to avoid drainage and to adapt themselves to the absorption rate of the plants.

Most common products are: urea formaldehyde -containing at least 36% of N, Crotonyliden diurea -with at least 30% of N, and Isobutyliden diurea -containing 30 Kg. of N per 100 Kg. of final product.

Mineral fertilizers protected by partially impermeable membranes can be included in this category.

Organomineral fertilizers with enzymatic inhibitors.

These fertilizers are synthesized by adding to conventional fertilizers substances that work as nitrification or denitrification inhibitors. They produce inherently slow biochemical reactions that end up stopping the corresponding reaction. The compounds better known and experimented on agricultural level are able to delay the transformation of ammonium ions into nitrite ions. Such substances are known as nitrification inhibitors. Currently they can be found in the market with added amounts of dicyandiamide (DCD).

The addition of nitrification inhibitors has also been experimented for livestock waste, with the purpose of delaying the nitrification of high concentrations of ammonium nitrate - present in manure, and thereby, increasing its efficiency.

Image 3. Granules of nitrogen fertilizer.

3.3. Aspects regarding the application periods of nitrogen fertilization.

Before entering the topics regarding direct applying of fertilizers, it is necessary to underline a series of concepts that will be useful to optimize fertilizer application and to minimize environmental impact associated with an inefficient management of fertilizers.

Nitrogen fertilization must be adapted in all aspects to the development of crops, taking into account the production capacity in every campaign.

Fertilizers are not immediately absorbed by the roots: they take some time to undergo decomposition, then they become soluble in the soil and finally get ready to be incorporated by the plant.

Image 4. Typical Olive Grove in Comarca de los Montes, Granada.

The extraordinary mobility of nitrogen due to its scarce retention in soil, with the subsequent risk of lixiviation, makes necessary the fractioning of the nutrient in the crops, according to its role in the vegetative cycle.

Fertilization fractioning enhances the crop performance, making available the nutrient when is needed the most, with the subsequent economic benefit. Also, it protects underground water against nitrate pollution, because it allows the monitoring of performance objectives as a function of crop evolution and climatological conditions - and adjusting the total dosage of such nutrient, avoiding excessive amounts. This is especially important in non-irrigated crops, where water is the limiting factor.

Nitrogen Forms.

The Nitrogen form present in the fertilizers is related with the application period, and therefore, with its behavior in the soil and how is used by the crops.

a) Fertilizers with **nitrogen in nitrate form**, a very mobile form in the soil, it´s more exposed to the processes of lixiviation and runoff, and because of that it is **more advisable its use** during the phenological stages where nutrient demand is higher, where the extraction of such nutrients is faster, i.e. **in basal fertilization and dose-fractionation**. The most important nitrogen fertilizers of nitric form are: Chilean Nitrate (15.5% N), Calcium Nitrate (15.5% N) and Potassium Nitrate (13% N).

Nitrogen Fertilizers in nitrate form are more exposed to lixiviation and runoff, and because of that, it is more advisable their utilization in basal fertilization and dose-fractionation.

b) **Nitrogen Fertilizers in ammonium form** have a slower absorption effect on the plant, because their higher retention in the soil, which make them more preferable for after-germination fertilization. The most important fertilizers with ammonium nitrogen are: anhydrous ammonia (82% d N), ammonium sulphate (20 – 21% N), ammonium nitrate solutions and ammonium phosphates.

Nitrogen in ammonium form shows a slower absorption effect on the plant, because of its higher retention in the soil, which makes it more preferable for after-germination fertilization.

c) **Fertilizers with nitrate and ammonium nitrogen**, because of their double nitrogen content, they provide more valid solutions to several fertilization problems regarding phenological and crop status. The most important nitro-ammoniacal products are: ammonium nitrate (33.5% N, half nitrate- half ammonium) and calcium ammonium nitrates (at least 20.5% N). There are solutions of ammonium nitrate and urea (at least 26% N) and ammonium nitro-sulphate (26% N, 7% nitrate and 19% ammonium).

d) **Nitrogen fertilizer in ureic form** is hydrolyzed quickly to its ammonium form in normal conditions of temperature, humidity, and pH; the process lasts approximately 3 to 10 days. This makes its action slower than in the ammonium forms. It must be handled carefully during the application period, because its solubility puts it under risk of runoff before becoming hydrolyzed. The most common product is urea (46% N), which is also the solid compound with the highest content of N.

Nitrogen fertilizer in ureic form shows a high solubility, so it won´t be applied during rainy season.

It is important to know that nitrogen cannot compensate the lack of other development factors. Therefore, it becomes fundamental to study the factors causing poor crops, by analyzing factors such as soil, climatology, plagues, illnesses, etc. before utilizing nitrogen to attempt recovery from an accident or mismanagement in the crop performance.

3.4. Olive Grove Fertilization.

3.4.1. General Aspects.

An excess of nitrogen is usually detected in olive groves, in the total balance of production zones. Although the input is usually applied directly to the soil, **foliar fertilization is recommended**, given that using this technique, the risk of soil pollution is minimized or practically eliminated.

It is possible to use foliar fertilization, instead of after-germination fertilization

The most part of nitrogen to be applied corresponds to the pre-flowering and fruit formation stages, and the rest of it, during the stage of fruit thickening, whenever pluviometry conditions are normal. Aside of these phenological periods, fertilization must not be carried out.

Apply nitrate, ammonium nitrate or ureic nitrogen during pre-flowering and fruit- formation stages. Apply nitrate during the stage of fruit thickening.

Fertilization must be carried out on the basis of nutrients availability, which can be known after implementing a foliar analysis. Leaf sampling for foliar analysis requires a strict protocol based on number and localization of the leaves to be sampled, their shape and the dates to carry out the sampling. Regarding the dates, they must be chosen according to the stage where the foliar nutrient contents are stable, -which usually occurs during July and winter season resting.

It is recommended to carry out fertilization on the basis of the results of foliar analysis.

Another aspect to take into account is the organic material content in the soil. A soil analysis must be carried out in order to determine the organic material levels; if the levels are too low (less than 1%), management must be oriented to its improvement, with vegetal covers or with the application of manure.

Green manure fertilization is recommended to improve soil fertility, by sowing legumes and burying them during their flowering stage. This practice can also be implemented using autochthonous vegetation.

Olive groves produce a series of sub-products tan can be beneficial to keep soil fertility and to improve its structure. Among them stand the pruning and mill residues. Mill residues in particular have a toxic effect in high doses, so they must be managed carefully during their application.

There are a series of products such as manure compost, WWTP (Wastewater Treatment Plant) sludge, vegetal compost, manure compost or vermicompost, grouped under the category of **organic amendments**. They consist of carbonated materials of vegetal and animal origin, utilized fundamentally to keep or increase the organic material contents of soil, improve its physical properties and also improve their properties and chemical and biological activity.

In the case of fertilizer from animal sources, it is convenient to be careful during its application, especially in livestock concentration zones. A maximum quantity of 20 Ton/Ha of manure or 40 m3/Ha of slurry in a three-year period can be incorporated.

Also, it is advisable to evaluate the pH of the soil to corroborate if it is in the optimal interval for Olive nutrition (6.3 to 8.5). If that is not the case, an expert must be consulted to consider the application of some kind of soil amendment or to incorporate fertilizer in an accessible way for the tree under those particular pH conditions.

Regarding nitrogen quantities, they must not be applied in amounts superior to 70 kg N/ha/year in a traditional non-irrigated olive grove. If the olive grove is modern- framed, this limit could reach 100 kg of N. If we are dealing with irrigated olive groves, the limits are 120 and 150 kg N/ha/year -for the traditional and intensive types, respectively.

During dry years*, with pluviometry lower than the normal for the zone, *it is advisable to avoid all types of fertilizers.

Image 5. Machinery used in foliar fertilization.

*** to remember**

1) Use foliar fertilizer if possible, instead of post-germinal fertilizer.
2) Provide nitrate nitrogen, ammonium nitrate or ureic nitrogen during pre-flowering, flowering and fruit formation stages. Apply nítrate nitrogen during the stage of fruit thickening.
3) Apply fertilizer according to the results of foliar analysis.
4) Do not apply nitrogen fertilizer during cold months on naked soil.
5) During dry years with pluviometry lower than normal for the zone, it is advisable not to apply any kind of fertilizer.
6) Fractionate the application of nitrogen fertilizer through several applications, and don´t apply fertilizer with high solubility nitrates and ammonium) during autumn and before the rainy season.
7) In poorly productive olive groves, do not apply fertilizer in excess. It´s possible that these olive groves need low fertilization, if they are being managed with covert and cattle grazing.
8) Apply organic fertilizer only during the beginning of the autumn season.
9) In olive groves with localized irrigation, fertilization will be implemented through fertirrigation, adjusting the timing to apply nutrients to the irrigation and the dosage to the requirements of the trees.
10) Any nitrogen form will be used as organic fertilizer.

3.4.2. Olive groves in steep slope terrains.

Regarding steep slope terrains we must take into account the types described in the Agrological classification, according to which, all terrains with **slope lower than 3% are classified as flat** and therefore, they lack of any inherent problem to the concept and allow permanent work on them. On the other side, terrains with slope superior to 20% are those which don´t allow mechanization due to their characteristics, and therefore, there is not possible to work on them, not even occasionally (except when these terrains are utilized with the purpose of keeping the vegetal covers to avoid erosion and soil loss). These terrains are better fitted to forestry-livestock use.

Therefore, this chapter will be focused in those terrains with slopes comprised between **3 and 20%, where permanent or occasional work is performed, and that undergo current erosion and runoff problems with nitrogen loss** as a function of a series of components such as nature and the direction of the vegetal covers implanted, parcel shape, soil characteristics, work carried out, fertilizers used and their time of application, etc. Also, these terrains can present **severe problems of soil losses.**

Image 6. Naked soils in steep slope terrains.

Erosion Control.

A proper management of vegetal covers ***prevent serious and irreversible water losses: increasing the infiltration capacity and water storage in the soil, by diminishing the speed of the water stream and by distributing the runoff uniformly, aside protecting the soil from erosion, provoked by the impact of rain drops***

The **utilization of conservation work techniques** in olive grove zones and extensive crops (with big representation in our Autonomous Community) brings a mitigation or, in the best-case scenario, avoids environmental degradation caused by hydric erosion and runoff pollution of superficial waters. The utilization of living vegetal covers (sown or natural) with good soil covers in the center of the streets is very effective in the battle against erosion and runoff.

Image 7. Conservation work in a steep-slope olive grove.

Image 8. Vegetal covers in the Olive grove.

In cultivation systems with reduced or minimum work, weed control is carried out with products applied to the soil next to the olives - during the autumn, on a previously smoothed terrain. During **April**, a one-time only crossed pass is executed using a vibrocultor, performing a second round perpendicularly to the maximum slope of the terrain, leaving the ground uncarved around the olives.

Another aspect to emphasize is the existence and preservation of **hedges and natural woody plants** in the perimeter of the parcel and those zones with higher slope, because they will work as a **barrier against runoff**; they will capture all the sediments and provide a landscape refugee for the auxiliary fauna. To enhance hedges growth it is recommended the utilization of arboreal or shrubby plants adapted to the zone, which must be planted following level curves.

Image 9. Lack of work in steep slope olive groves.

In steep slope terrains with serious erosion problems found, such as gullies and groves, the installation of fiber rolls and organic covers elaborated using vegetal fibers -can be implemented. **Fiber rolls (also known as fiber logs or straw wattles)** are installed perpendicularly to the runoff lines over the hillside and they work as barriers, helping to capture soil particles swept away by the water, preventing the deepening of the gullies. Occasionally, fiber rolls are sited on flexible containers filled with stones, to improve their stability on the terrain.

In the framework of the Project LIFE + EUTROMED, developed by the Granada Local Government, these systems are currently being installed in Comarca de los Montes, with the double goal of preventing nitrate pollution and soil erosion.

Image 10. Gully treated with fiber rolls and organic layer in the framework of the project EUTROMED.

*** to remember**

1) Limit the use of liquid fertilizers in terrains where slopes are prone to runoff.

2) Avoid the application of solid fertilizers during the rainy season.

3) Use conservation work techniques to mitigate or prevent hydric erosion and runoff pollution.

4) Using vegetal covers on streets perpendicularly to the slope increases the filtration capacity, diminishes water stream speed and protects the soil from the erosion caused by the impact of raindrops.

Image 11. Olive grove in slope

3.4.3. Olive groves near to water streams.

Regardless of the pollution that might be produced in water streams due to infiltration or drainage, at this point the potential pollution of superficial waters must be taken into account, caused by branching or drainage. In this case, the factors causing water stream pollution are: composition of the shore (especially topography and vegetation), width of the floodplain, fertilizer form, spreading equipment and livestock management on these terrains.

Topography and la vegetation of the shore can enhance or restrict branching or drainage, depending on the presence of embankments (height, Distance from the shore, etc.), slope accentuation regarding the shore, presence or absence of vegetation and vegetation characterization (gallery forest, prairies, hedges, etc.)

A proper regulation of the fertilization equipment prevent projections (centrifugal distributors, manure spreaders, spray guns) towards inconvenient zones, as well as drainage in case of equipment stopping (liquid fertilizer bar, barrel of manure, etc.)

To **prevent contamination**, a safety margin of 35 to 50 meters is recommended, without any organic fertilizer (particularly manure). This measure is also applicable for wells, boreholes and sources of water for human consumption or potable waters in general.

The use of fertilizers with coarse granulometry is strongly recommended, because the ones with thin granulometry are carried away or dissolved easily.

Image 12. Ditch for transport of irrigation water

*** to remember**

1) To delimit a safety margin of 2-10 meters where fertilizer will not be applied.

2) To maintain a safety margin of 35-50 meters where organic fertilizers won´t be applied.

3) To prevent the concentration of livestock during the direct watering on water streams.

4) To avoid liquid fertilizers in order to prevent runoff through the water stream.

5) To apply fertilizer in absence of rain and wind.

6) To use distribution equipment fitted to prevent branching due to lack of accuracy, and to implement an efficient regulation of the manifold.

7) To maintain the vegetal cover to prevent the risk of runoff pollution.

Image 13. Reservoir surrounded by Olive grove terrains.

IRRIGATION MANAGEMENT

4. IRRIGATION MANAGEMENT.

The use and management of agricultural soils – on an exploitation level or just parcel level- is fundamental when dealing with the **risk of water pollution by nitrogen**, so preventive measures must be taken to mitigate this risk as much as possible. Irrigation techniques are very influential to this purpose, besides the fact that a reasonable fertilization might be enough. In this sense, it is convenient to adopt specific irrigation techniques for each crop and each zone or application area, instead of a general model.

It is obvious that society is exerting an increasing pressure towards the current environmental problematic regarding water use and nitrogen fertilizers and their impact. On the risk zone near to Guadalquivir River there are areas of medium to high porosity, causing a high vulnerability risk.

Because of these reasons, a proper irrigation management is very important, paired with fertilization management.

Image 14. Fertirrigation in Olive grove.

The risks of nitrate pollution, due to lixiviation or superficial drainage, associated to an inadequate management of irrigation, are undoubtedly of great importance, with the aggravating waste of resource and the energy employed when this situation occurs.

Under conditions of high precipitation or abundant irrigation, vertical shift of nitrogen is facilitated from the soil profile horizon to depths far away from the roots, where it cannot be absorbed by the plants. Nitrogen is transported by water flow through underground streams (lixiviation). **High concentrations of nitrate in superficial waters are responsible factors for eutrophication** (uncontrolled development of superficial algae causing hypoxia or lack of water oxygen), whereas its presence in underground waters (used as potable water) constitutes a health risk, since nitrate is a precursor molecule for the synthesis of toxic compounds.

Nitrate pollution risks during irrigation

Risks of pollution from irrigation sources are subject of variation according to the characteristics of the soil (permeability, field capacity, depth, slope, level of the groundwater, etc.), agricultural practices (fertilizer type, crop rotation, soil work, etc.), the irrigation method and its utilization.

Zones where irrigation constitutes a **high risk**, especially regarding nitrogen loss and soil, show at least one of the following characteristics:

- Sandy soils very permeable and with restricted field capacity.
- Presence of a superficial groundwater layer (depth lower tan 15-20 cm) over fissured rock.
- Terrains with slope superior to 3%.
- Intensive agriculture with high supply of fertilizers.
- Terrains rich in organic matter and frequently carved in depth, among others..

Zones of **moderated risk** present the following most relevant characteristics:

- Soils of medium granulometry, low permeability and discrete field capacity, presence of groundwater layer in a range of 2-20 meters.
- Soils of medium depth (not inferior to 50-60 cm)
- Soils of moderated slope and discrete supply of fertilizers.

Zones of **low risk** are those with:

- Clay soils of little permeability and high field capacity.
- Deep soils (superior to 60-70 cm).
- Presence of groundwater layer to over 20 meters.
- Terrains with slight slope.

Choosing Irrigation method.

To reach high efficiency values in water distribution, the irrigation method plays a protagonist role, so the implementation of inundation or layer irrigation is recommended.

Image 15. Drip Irrigation System.

The **main agronomic factors** critical to choose the irrigation method are the physical, chemical and orographic characteristics of the soil, the requirements and/or characteristics of the crops, the quality and quantity of available water and climatic factors.

To prevent loss of nitrates during irrigation by inundation and deep percolation, such method must be applied only in deep terrains with clay soil and crops with a deep root system, with a frequent demand for irrigation.

Image 16. Distribution system of ditches for irrigation by inundation.

In the case when **irrigation by aspersion is applied**, in order to prevent nitrate loss by drainage and superficial runoff, it is advised to pay special attention to the distribution of the sprinklers along the parcel, the intensity of pluviometry regarding soil permeability, the wind interference over the sprinklers diagram distribution and the influence of vegetation over the distribution of the water over the terrain.

Image 17. Irrigation by sprinklers.

In the case where **fertirrigation** is applied, it must be implemented using methods to ensure a high efficiency in the water distribution from the beginning of the irrigation, to prevent pollution events, preferably after the supply of 20-25% of the total water volume.

Fertirrigation must be completed when the 80-90% of the total volume of water has been supplied.

Image 18. Spraying on irrigation zone using agrimotor.

In localized irrigation systems, a high salt concentration occurs on the surface of the humid "bulb", if the irrigation is by drip system, or in the surrounding zone separating the humid area from the dry area. To correct these high-concentration zones, it is recommended a periodic variation of the flow and timing of irrigation.

In very expansive soils, long irrigation is not advisable, to avoid the formation of a deep cracking -which could facilitate the loss of big volumes of water through deep strata, with the subsequent transport of lixiviation solutes from superficial strata.

Image 19.

Self-compensating dripper .

*** to remember**

1) A good irrigation practice prevents percolation and runoff of superficial water and its nitrate contents, reaching high efficiency in water distribution.

2) Apply fertirrigation whenever it´s possible, given that the following goals can be achieved:

- Rational dosage with higher efficiency and rentability of the fertilizers
- Optimized nutrition as a function of soil type, chemical composition of the Irrigation water and weather.
- Pollution control by preventing the excess of nutrients
- Ability to adapt fertilizers to the phenological stages of the crop.

CONCLUSIONS

5. CONCLUSIONS.

It´s evident that nowadays society is exerting an increasing pressure to the environmental problematic derived from the Irrigation and nitrogen fertilizers. When misused, nitrogen can cause negative impacts on the environment, such as water pollution by nitrates. Generally, this is consequence of an agricultural malpractice by farmers and ranchers. But certainly, the interest that the agricultural sector has developed towards this issue, must not be conditioned solely on the basis of external pressure, but mainly because of the benefits that would bring for them a proper management of nitrogen fertilization together with an efficient irrigation method.

The farmer, armed with a good management of labor and maintaining a good soil structure and a proper content of organic matter, can positively influence in the reduction of pollution. In this sense, a proper balance of nutrients, fertilization planning and good agricultural practices are essential to prevent nitrate pollution of superficial waters.

Keeping an annual record of concrete situations can help the farmer to reach quickly an optimization of the fertilization, with the subsequent protection and conservation of superficial waters and groundwater. To pursue that goal, there are a number of software programs that take into account the physicochemical soil analysis, mean pluviometry of the zone and the collection during crop development, the expected and mean production, the previous crop and next crop and the organic improvements applied, giving as a result optimum units to be applied, momentum and type of fertilizer.

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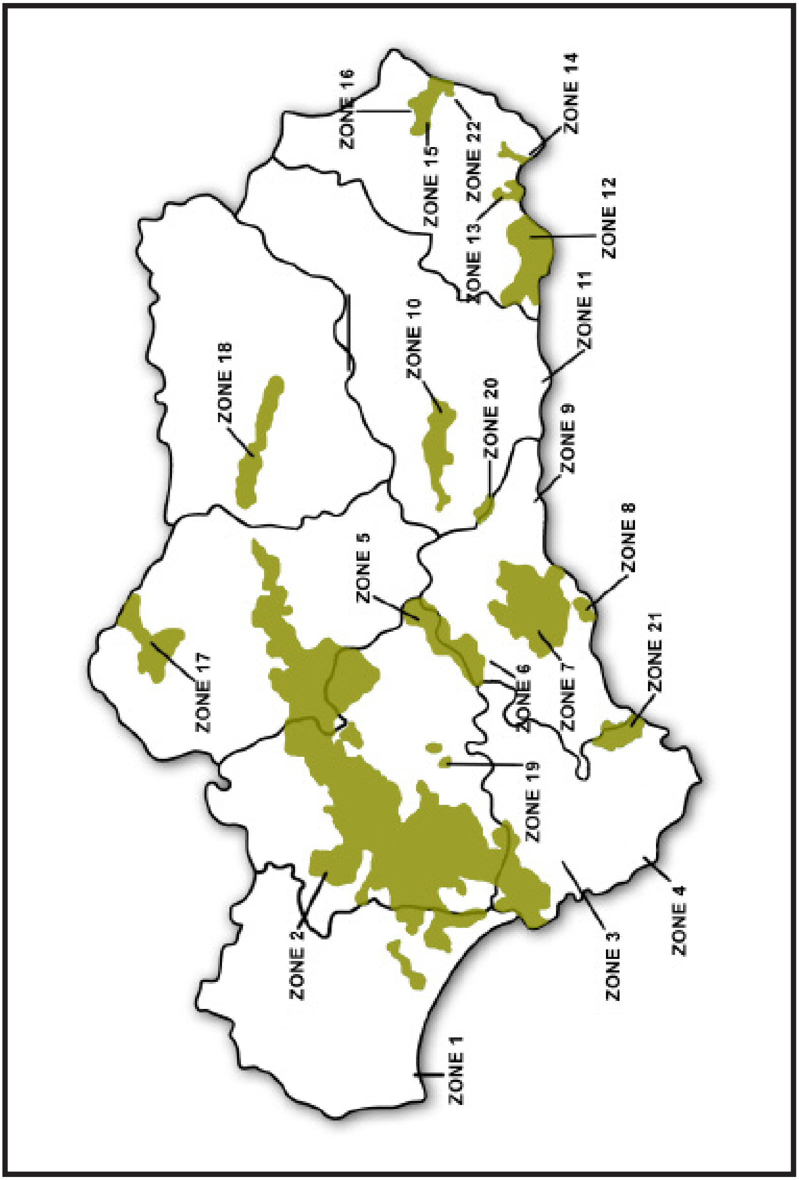
ANNEX

ANNEX.
LIMITATIONS, OBLIGATIONS AND RECOMMENDATIONS FOR ZONES DESIGNATED AS VULNERABLE TO NITRATE POLLUTION.

The Decree 36/2008, of February 5th, regarding the designation of vulnerable zones and the establishment of preventive measures against nitrate pollution from agricultural sources, comes to designate, following directives of the UE, new more precise delimitations of vulnerable zones and establish measures against nitrate pollution from agricultural sources.

Designated vulnerable zones are represented graphically in the following map in this Annex. The zones correspond to enclosures destined for agricultural use and livestock intensive exploitation, located at the SIGPAC polygons numbered in the Annex II of the same Decree, together with the indication of affected water masses.

Map 1. Annex I -Decree 36/2008.
Map of Zones vulnerable to nitrate pollution in Andalucía.



Map 1. Annex I -Decree 36/2008.
Map of Zones vulnerable to nitrate pollution in Andalucía.

Zone 1: Ayamonte-Lepe-Cartaya
Zone 2: Valle del Guadalquivir
Zone 3: Valle del Guadalete
Zone 4: Vejer-Barbate
Zone 5: Vega de Antequera
Zone 6: Cuenca del Embalse de Guadalteba
Zone 7: Bajo Guadalhorce
Zone 8: Río Fuengirola
Zone 9: Aluvial del río Vélez
Zone 10: Vega de Granada
Zone 11: Litoral de Granada
Zone 12: Campo de Dalías-Albufera de Adra
Zone 13: Bajo Andarax
Zone 14: Campo de Níjar
Zone 15: Cubeta de Ballabona y río Antas
Zone 16: Valle del Almanzora
Zone 17: Cuenca del embalse de La Colada
Zone 18: Guadalquivir-curso alto
Zone 19: Arahal-Coronil-Morón-Puebla de Cazalla
Zone 20: Sierra Gorda-Zafarraya
Zone 21: Guadiaro-Genal-Hozgarganta
Zone 22: Rambla de Mojácar

Table 1. Extract of Annex II -Decree 36/2008.

SIGPAC Polygons of Zones vulnerable to nitrate pollution in "la Vega de Granada".

ZONE 10 : VEGA DE GRANADA

ZONA	PROVINCIA	MUNICIPIO	PRO	MUN	POLÍGONO																															
10	GRANADA	Albolote	18	4	14	15	16	17	18	19	20	21	23	24	25	27																				
10	GRANADA	Alhendin	18	15	1	2	3	4	5	16																										
10	GRANADA	Armilla	18	22	1	2	3	4																												
10	GRANADA	Atarfe	18	23	14	15	16	17	18	19	20	22	23																							
10	GRANADA	Cijuela	18	49	1	2	3	4	5	6	7	8																								
10	GRANADA	Cúllar Vega	18	58	2	3	4																													
10	GRANADA	Chauchina	18	60	1	2	3	4	5	6	7	8	9	10																						
10	GRANADA	Chimeneas	18	62	1	2	3	4	12	18	19	20	21																							
10	GRANADA	Churriana de la Vega	18	64	1	2	3	4	5																											
10	GRANADA	Dilar	18	62	1	11																														
10	GRANADA	Fuente Vaqueros	18	81	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18														
10	GRANADA	Gabias (Las)	18	83	1	2	3	10	11	12	13	14																								
10	GRANADA	Gójar	18	86	1	2	4																													
10	GRANADA	Granada	18	900	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	22																
10	GRANADA	Huétor de Santillán	18	101	5																															
10	GRANADA	Huétor Tájar	18	102	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16																
10	GRANADA	Huétor Vega	18	103	1																															
10	GRANADA	Illora	18	104	13	14	15	16	17	18	19	20	21	22	23	24	40	41	42	43	44															
10	GRANADA	Jun	18	113	1																															
10	GRANADA	Láchar	18	117	1	2	3																													
10	GRANADA	Loja	18	123	9	12	13	24	25																											
10	GRANADA	Maracena	18	128	1	2	3	4																												
10	GRANADA	Moraleda de Zafayona	18	140	1	2	3	4	5	6	7	8	9	13	14	15	16																			
10	GRANADA	Ogíjares	18	148	1	2	3																													
10	GRANADA	Otura	18	152	1	2	3	4	6	9																										
10	GRANADA	Peligros	18	156	6																															
10	GRANADA	Pinos Puente	18	161	3	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
10	GRANADA	Pulianas	18	168	3	4	5																													
10	GRANADA	Salar	18	174	1	4	16																													
10	GRANADA	Santa Fe	18	178	1	2	3	4	5	6	7	9	10	11	12	13	14	15	16	17	18	19	20	21												
10	GRANADA	Vegas del Genil	18	20	3	4	5	6	7	8	9	10	11	12	13	14	15																			
10	GRANADA	Villanueva Mesía	18	192	1	3	4																													
10	GRANADA	Víznar	18	193	5																															
10	GRANADA	Zubia(La)	18	197	1	2	3	4	9																											

The limitations, obligations and recommendations regarding Good Agricultural Practices in zones designated as vulnerable -are established in the Order of November 18th 2008, approving the Program of Action applicable to zones vulnerable to nitrate pollution from agricultural sources, as designated in Andalucía (BOJA # 4, 1/08/2009) and its amendments(BOJA # 40 27/2/2009).

The following list is a summary of **obligations** affecting **olive grove cultivation.**

OBLIGATIONS regarding the tme of application of nitrogen fertilizers to the olive grove terrain.

- **ORGANIC FERTILIZERS**: use in first application.
- **MINERAL FERTILIZERS:**
  - **Fertilizers in ureic, ammonium, slow-release or nitrification-inhibitor forms:** use in first input in covers.
  - **Fertilizers in nitrate or nitrate-ammonium forms:** use in second application and posterior applications in covers.
- **FERTIRRIGATION:** do not apply any of the previous obligatory limitations.

PROHIBITIONS regarding the application of nitrogen fertilizers to the olive grove soil.

- **For ORGANIC FERTILIZERS**:
  - **Exceed 170 Units of Nitrogen Fertilizer.**
    (UFN equivale a 1 kg de N).

- **Application of FERTILIZERS during:**
  - **Rain periods.**
  - **Frozen or snow-covered soils**
  - **Flooded or water-saturated soils.**
  - **Parcels with average slope > 15 %**
  - **Margin of 10 meters from water streams or accumulation areas.**

- **FRINGE OF 10-50 M on terrains nearby water streams:**
  - **Apply fertilizer during windy days.**
  - **Use liquid fertilizers** (except in fertirrigation).
  - **Use organic fertilizers.**

Specific PROHIBITIONS and RECOMMENDATIONS for the irrigated olive grove.

- **FORBIDDEN:**

    - **Exceed 25 UNF per ton of expected production**
      (UNG equals 1 kg of N).

- **RECOMMENDED ACTIONS:**

    - **In Fertirrigation:**
        - Adjust application to crop necessities.
        - Carry out nitrogen analyses of Irrigation water every two years.
    - **Carry out foliar analysis every two years.**
    - **Carry out soil analysis every four years.**

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