



Closing the mineral cycles
at farm level

Good practices
to reduce nutrient loss
in the **Murcia** region
(Spain)

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Nutrient loss – Why does it matter?

Nitrogen, phosphorus and potassium are essential for agricultural production as they nourish the crops and support soil productivity. However, if these nutrients are not taken up by plants, they run the risk of being lost in various ways (e.g., leaching, run-off, emissions) and causing unnecessary costs for the farming business. Finding the right amount required by the plants and optimising the timing and application of the nutrients to match these needs can result in an economic gain and a positive effect on human health and the environment, including soil health and fertility.

This leaflet was developed in the framework of the project “Resource Efficiency in Practice – Closing Mineral Cycles”. It aims at providing practical information to farmers on how the risk of nutrient loss can best be minimised or prevented. In particular, the leaflet addresses the effects of nutrient loss in Spain, with a specific focus on the Murcia region. The leaflet also provides practical information to farmers on how resource use efficiency can be maximised through good practices at farm level.



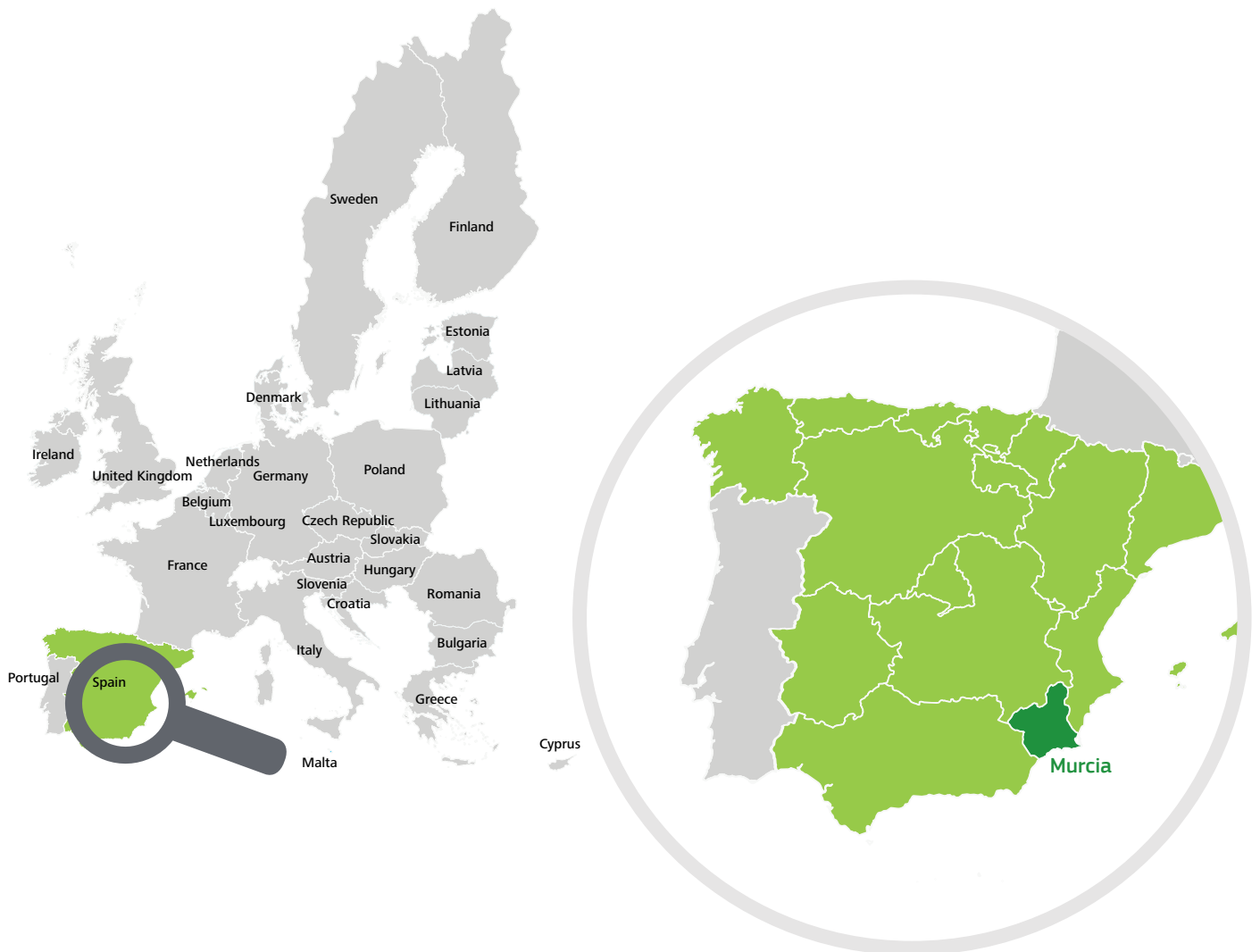
Jellyfish (*Cotilorhiza tuberculata*) caught in the jellyfish net inside the bathing area in Mar Menor.

Agricultural structure in Murcia

Murcia is the second most important region for horticulture in Spain with half of the region's area dedicated to agricultural production. Citrus fruits, almonds, vegetables, melons, strawberries, and flowers as well as cereals (rye and oats) are produced in the region. Regarding livestock, pig farming is the most prevalent in Murcia (6.6% of the

total production in Spain) followed by sheep. Since the 1980s, Murcia has altered streams to divert river water to the region and extracted water for irrigation purposes, shifting its land use from the production of extensive dry crops to intensively irrigated crops. (1) With this intensification, the use of pesticides and fertilisers (organic and mineral) has also increased.

Figure 1 - Map of Europe (Spain in green) and map of Spain showing the Murcia region in dark green



How does nutrient loss affect farming business?

Nutrients are valuable and vital resources, which can nourish productive grazing lands and crops. From an economical point of view, it therefore makes sense to match the nutrient application to the grassland and crop requirements, thus limiting nutrient loss as much as possible. This in turn could limit the additional costs (e.g., tractor fuel, spreading equipment, labour, etc.) incurred when nutrients are applied beyond the crop and grass requirements. However, over-fertilisation is also owed to the shallow root depth of horticulture. As nutrients easily reach soil depths inaccessible by plant roots, farmers apply more fertiliser more frequently to provide sufficient nutrients to the crops. In addition, nutrient loss can create other costs for the farmer, such as the purchase of more mineral fertiliser to supplement for lost nutrients and reach the level of the plants' needs. Avoiding the impacts that may result from nutrient loss provides benefits to farming businesses, such as maintaining soil health and fertility and crops yields.

How does nutrient loss affect the Murcia region and what are the causes?

Murcia faces a number of environmental pressures stemming from different sources. The Albuñón River and Segura River Basins, for example, have nitrate concentrations exceeding the value of 50 mg/L as a result of industry, urban- and agriculture-related activities. Due to open storage of pig slurry in the region, ammonia emissions occur at a fairly high rate and result in deposition of additional nitrogen compounds on soils, forests and water bodies. Phosphorus overloads also result from agricultural run-off and urban wastewater and affect the composition of freshwater bodies, such as the Santomera reservoir, the Albuñón River, the Segura River and the Mar Menor.

Intensive agricultural systems, especially those which use gravity irrigation and create high water flows for long intervals, increase the risk of nutrient losses to rivers and lagoons in Murcia. Additionally, despite the generally semi-arid climate, heavy rainfall events in autumn can cause nutrient leaching. A factor contributing to nutrient loss and little soil water storage in Murcia is the low organic matter content in the soils. Nutrient overload in the Mar Menor lagoon has dramatically increased the jellyfish population during summer, thereby directly affecting biodiversity and tourism in the region. In addition, the local fishing industry has been negatively affected due to impacts on the feeding grounds of several commercial fish species.



Drip irrigation to reduce water use and nutrient losses, here for melon production

What has already been done to address the problem in the region?

The Mar Menor area, the irrigated farmland in the middle of the Segura Valley and the Guadalentín Valley have been designated nitrate vulnerable zones (NVZs) covered by mandatory measures under the Nitrates Directive, such as limiting application of livestock manure to a maximum of 170 kg nitrogen ha/yr. In Murcia, a cooperative project between the Consejería de Agricultura y Agua, the Politechnical University of Cartagena and the agriculture cooperative FECOAM was set up to assist farmers in the sustainable use of pig manure as an organic fertiliser and help to reduce the nutrient surplus caused by pig slurry inputs. Additionally, drip irrigation was installed to cope with the dry weather conditions on 83% of the irrigated area in the region as of 2013. (2) Murcia's Rural Development Programme under the EU Common Agricultural Policy has also acknowledged the importance of preventing soil erosion and the benefits of measures such as buffer strips in combating nutrient losses through funding such measures.



Suckling pigs on a modern hog breeding farm

Set of region-specific good practices

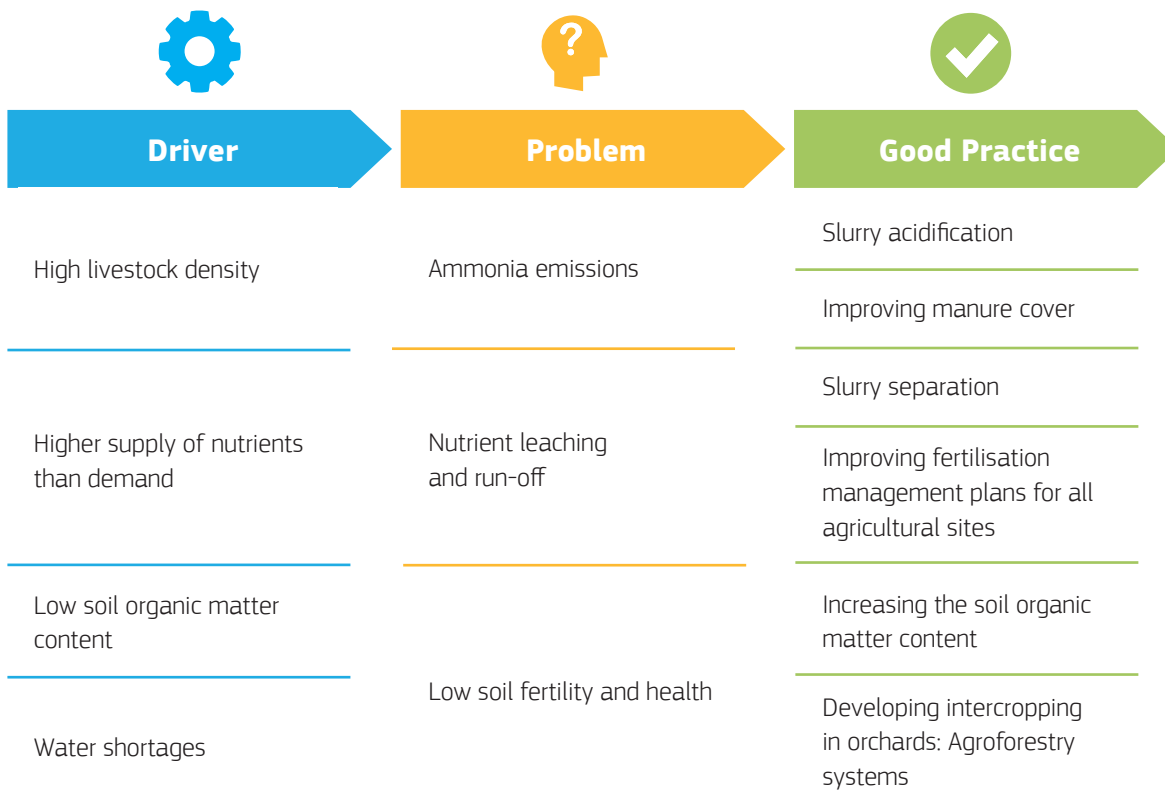
Several examples of ‘good practice’ measures to reduce nutrient loss and increase resource efficiency in the Murcia region have been identified (see Figure 2) and will be described in more detail in the following tables.

The measures were selected based on their impacts on the agro-ecosystem in terms of reduced losses through improved nutrient utilisation. Thus, the selected measures provide some economic advantages for the farmer and at the same time

reduce nutrient loss from the farming system, benefitting both the environment and society. Emphasis was placed on measures that have not yet been exploited to their full potential within the Murcia region. Further selection criteria were whether the measure might be feasibly implemented and whether the measure offers benefits which balance (or outweigh) the costs.

The graphic below highlights various drivers of nutrient loss which exist in the Murcia region and problems which are related to those drivers. The final column presents the good practices that were identified as ways to potentially solve the problems associated with nutrient loss.

Figure 2: Selection of good practice measures for the Murcia region



Improving manure processing: Slurry acidification



Definition of the measure	By adding acid to livestock slurry, the pH of the slurry is reduced to around 5.5 and the equilibrium between ammonia and ammonium is shifted towards ammonium, thereby reducing ammonia emissions to the air.
Technical implementation	Sulphuric acid is a form of acid that can be applied to manure to limit the ammonia volatilisation. It is possible to acidify the slurry under the slats in the barn, in the slurry tank during storage, or at the time of field application using a system mounted on the slurry trailer. Standard spreading equipment can be used to handle the acidified slurry.
Technical requirements	Commercial equipment is available for acidification under the slats in the barn, in the slurry tank during storage, or on the slurry trailer during field application.

Effects, benefits and costs

Benefits for farming business	Higher amount of nitrogen available for the crop, which may increase crop yields and reduce the amount of additional mineral fertiliser needing to be purchased and applied.
Costs for farming business	Initial investment in acidification equipment for use in stables, slurry tanks, or during field application. Additional expenses include running costs for sulphuric acid and extra costs for liming due to soil acidification. (3)
Co-benefits and trade-offs	Acidification of slurry results in a long-lasting decrease of methane production. The greatest effect is achieved by acidifying the slurry already in the stable, whereas there will be no effect on methane emissions if acidification takes place immediately before field application.
Environmental effects	<p>Air: Decreased ammonia emissions leading to less particulate matter, odour, and ozone formation, which lowers risks to human health (e.g., aggravated asthma and respiratory problems);</p> <p>Reduced greenhouse gas emissions (methane), thereby decreasing the impact on climate.</p> <p>Biodiversity: Positive effects from reduced N deposition in natural ecosystems.</p>



Improving manure cover

Definition of the measure

In Murcia, manure is stored in large, open manure ponds to increase evaporation and dry the manure as fast as possible. This approach causes high ammonia and methane emissions, which can be reduced by covering the stored manure. Manure coverage decreases the surface area from which emissions can occur. Sealing the existing ponds with covers would decrease the amount of nutrients lost.

Technical implementation

Manure in Murcia is mainly a product of pig breeding. Pig manure contains a low percentage of dry matter and requires straw or other materials to form a crust. Therefore, it is especially prone to ammonia volatilisation when left uncovered and exposed. Fixed covers are more efficient in achieving emission reductions and diverting rainwater collection. Flexible covers can be implemented in different ways, e.g., straw, clay, fleece, and foils are some possible covers. (5) Straw adds organic matter to the manure, which benefits soil quality if the manure is then applied on the field. Additionally, if the manure is cooled, volatilisation decreases and the N content would be higher.

Technical requirements

High initial investments are needed for fixed covers. Flexible covers have lower associated costs. Fixed coverage may be impractical for solid manure, as the regular addition of manure to the storage structure (daily, twice weekly) requires removal of the cover. Nevertheless, solid manure emits a higher amount of greenhouse gases than separated slurry. Thus, since the emission reduction potential is high, adoption of this measure should be considered where feasible.

Effects, benefits and costs

Benefits for farming business Cost-savings from reduced mineral fertiliser purchase and application due to higher nutrient content of stored manure (obtained by covering with a semi-permeable or impermeable cover).

Costs for farming business Construction and increased operating costs for maintenance and handling of the covered manure storage facilities. Fixed covers are more expensive than flexible covers, especially if not foreseen in the storage design.

Co-benefits and trade-offs Manure nutrient levels need to be calculated to match the crop needs; otherwise, application of the same quantity of manure would result in higher nutrient levels and potential losses.

Environmental effects Decreased ammonia emissions leading to less particulate matter, odour, and ozone formation, which lowers risks to human health (e.g., aggravated asthma and respiratory problems); decreased ammonia emissions will also result in benefits to water and natural ecosystems.
Reduced greenhouse gas emissions (methane), thereby decreasing the impact on climate.

Improving manure processing: Slurry separation



Definition of the measure

Separation of pig manure in Murcia is crucial in order to deal with the liquid fraction or slurry, which contributes high ammonia emissions if it evaporates. Manure separation enables improved utilisation of the nutrients in livestock manure, thereby reducing the losses and the associated environmental impacts. Livestock manure is separated into a liquid N-rich fraction and a solid P-rich fraction. The solid fraction is subsequently exported away from the livestock intensive farm, thereby decreasing the P load on the farm where it originated and providing a soil additive to increase the soil organic matter content on a nutrient-deficient farm. The liquid fraction can be used, after filtration, in fertigation installations. As slurry can contain pathogens, the fertiliser should only be used in the production of non-edible crops (i.e., flowers) or tree crops.

Technical implementation

To avoid ammonia volatilisation, acid (sulphuric acid) might need to be added. As both fractions contain nutrients, they should be analysed to determine the available nutrients for fertilisation management.

Due to the relatively high investment and operating costs for slurry separation systems, this measure has a significant economy of scale. Mobile solutions, where a group of farmers share a slurry separation system, may be an option.

Technical requirements

Source separation of slurry requires specific livestock housing designs and is therefore mainly suitable when constructing new stables. Alternatively, separation may take place using a separator after the manure has been removed from the stable. To limit ammonia emissions, the solid fraction should be separated shortly before it is applied or covered with an airtight cover during storage and additionally be treated with sulphuric acid. When applied as organic fertiliser, slurry needs to be incorporated rapidly following application in the field.

Effects, benefits and costs

Benefits for farming business Improved crop utilisation reduces the need for purchase and application of additional mineral fertiliser.

Costs for farming business

Initial investment in livestock housing designed for manure separation or an external separator. (4) Additional costs include significant operating expenses.

Co-benefits

Slurry separation enables acidification of the liquid fraction, thereby reducing ammonia emissions. A further benefit is the reduction of greenhouse gas emissions during the production of fertilisers if less additional inorganic fertiliser is applied.

Environmental effects

Water: Reduced losses of nutrients (P and potentially N), decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.

Air: Potentially decreased ammonia emissions depending on management (e.g., airtight cover on the stored solid fraction), leading to less particulate matter, odour, and ozone formation, which lowers risks to human health (e.g., aggravated asthma and respiratory problems);

Potentially reduced greenhouse gas emissions (carbon dioxide due to less fertiliser production), thereby decreasing the impact on climate.

Soil: Improved soil fertility through use of the liquid fraction as a fertiliser.

Biodiversity: Positive effects from reduced N deposition in natural ecosystems.



Improving fertilisation management plans for all agricultural sites

Definition of the measure

Preparation of fertiliser management plans which include more than the basic nutrient balance by using specific tools (e.g., soil analysis) and accounting for all relevant inputs and outputs (e.g., deposition, fertilisation, crop residues) allows the amount of nutrients applied to be optimised to the conditions of the land (soil type, crop demand, and remaining nutrients).

Basing organic and inorganic fertiliser application rates on a calculated nutrient balance can considerably reduce nutrient losses. More effective nutrient management plans (considering additional factors in the nutrient balance) could be devised beyond the basic requirements of the Nitrates Action Programme and the practices included within the Good Agricultural and Environmental Conditions (GAECs).

Technical implementation

Calculate and interpret the site-specific nutrient balance:

Analyse the parcel-specific remaining nutrient content in the soil considering the soil type and mineralised crop residues;

Determine the crop nutrient requirements for the desired yield under the given environmental circumstances;

Analyse the nutrient content of organic fertilisers, establish the ratio to mineral fertilisers to fully satisfy crop needs, and consider the time lapse between the application and the assimilation of nutrients by crops.

Technical requirements

The measure involves the calculation of N, P and K leftover in the soil and adjustment of the amount of fertiliser to be applied in the next growth period. This is based on soil samples taken in the spring and autumn (N_{min}), which also serve as a monitoring element of this measure. Nutrient application is fine-tuned according to the crop type and the local conditions. The Sistema de Información Agrario de Murcia (SIAM) supports the calculation of remaining nutrient levels. (6) This system provided by the Research and Development Institute for Agriculture and Food in Murcia (IMIDA) supports the calculation of nutrient levels in water and provides information on current weather conditions and crop-specific nutrient demands.

Effects, benefits and costs

Benefits for farming business Cost-savings from reduced purchase and less application of additional fertiliser.

Costs for farming business Soil analyses, increased management efforts when applied to all sites, and potentially additional technical support to balance the N, P and K budget (e.g., consideration of remaining nutrient content).

Co-benefits and trade-offs The reduction of applied nutrients positively affects nutrient loss provided that the application takes place under suitable conditions (including weather conditions). A further benefit is the reduction of greenhouse gas emissions during the production of fertilisers if less additional inorganic fertiliser is applied.

Environmental effects

Water: Reduced leaching and run-off of nutrients (N, P, and K), decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.

Soil: Improved soil fertility and health through reduced potential for acidification.

Air: Decreased ammonia emissions leading to less particulate matter, odour, and ozone formation, which lowers risks to human health (e.g., aggravated asthma and respiratory problems);

Reduced greenhouse gas emissions (nitrous oxide and carbon dioxide), thereby decreasing the impact on climate.

Biodiversity: Positive effects from reduced N deposition in natural ecosystems.

Increasing the soil organic matter content



Definition of the measure

In Murcia, soils are generally poor in soil organic matter (SOM). Therefore, water and nutrient retention capacities are limited. The use of organic fertilisers, green fallow or the incorporation of crop residues increase the SOM content and improve soil structure. Thus, the retention capacity of the soil improves and the risk of soil erosion decreases.

Technical implementation

The application of **organic fertilisers** such as manure, compost or substrate from biogas production does not only increase SOM content but has to be treated as a nutrient input. Therefore, the amount of mineral fertiliser should be adapted to the amount of nutrients applied with the organic fertiliser. To avoid over-fertilisation, the substrate should be analysed for the contained nutrients.

Green fallow with legumes additionally provides biological nitrogen fixation. Incorporation of the plants into the soil does not only increase SOM, but the mineralisation of the plants sets nitrogen compounds free to be taken up by the main crop. Therefore, the amount of nitrogen in the soil needs to be considered in the fertilisation plan.

Crop residues can be cereal straw or residues from the cultivation of other crops, such as sunflower, rapeseed or horticulture, or biomass arising from the pruning and cutting of permanent crops (orchards, vineyards, etc.). They can be left in the field or applied to another field. The incorporation of residues provides not only N, P, and K but also carbon into the soil, avoiding the addition of inorganic fertilisers. However, this may increase N leaching from soil.

Technical requirements

Incorporation and management is mainly beneficial for soils which are well aerated or which have high clay contents. Tillage accelerates decomposition of organic residues in the soil.

Effects, benefits and costs

Benefits for farming business Increased soil health, nutrient and water retention; cost-savings from less mineral fertiliser use, especially when legumes are used.

Costs for farming business Additional labour for seeding, ploughing and preparation of residues (e.g. transport from one field or orchard to another); costs for seeds when applying green fallow. Due to the high demand for manure in Murcia, purchasing costs for manure are high if manure is not available or insufficient on farm.

Co-benefits and trade-offs Crop residues, organic fertiliser and green fallow provide soil with components that enhance SOM and contribute to soil fertility and ecosystem health. There is a risk of releasing direct nitrous oxide emissions when incorporating cover crops and crop residues into the soil (particularly with legumes). However, composting residues may help to reduce nitrous oxide emissions.

Environmental effects
Soil: Improved soil fertility and structure, water retention capacity, and soil biodiversity through increased soil organic matter and reduced risk of soil erosion, contributing to carbon sequestration and storage in the soil.
Water: Reduced risk of leaching and run-off of nutrients by increasing plant uptake and root retention, decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity.
Air: Reduced greenhouse gas emissions (carbon dioxide) due to reduced production of fertilisers.



Developing intercropping in orchards: Agroforestry systems

Definition of the measure

Agroforestry entails growing crops or livestock together with trees inside agricultural parcels or on their boundaries. The objective is to increase the capture of nutrients by root systems and thereby reduce nutrient leaching and avoid nutrient loss through soil erosion. Particularly in the Murcia region, water shortages in crop production could benefit from the trees' shade, which lowers evapotranspiration rates. In the orchards in Murcia, this technique can also be applied in order to avoid barren soil between the tree lines despite social pressure to conform to traditional management.

Technical implementation

Depending on the crops, different designs are possible:

Alley cropping: implementation requires a good understanding of space, light and the nutrient demands of the crops in the system, which can vary between monoculture and mixed cultures.

Riparian buffer strips: planting can consist of three zones - Zone I (width ca. 10 m) at the river bank with trees that withstand flooding; Zone II (width ca. 3 to 5 m) consisting of native shrubs which store nutrients; and Zone III (width ca. 5 to 8 m) containing native grasses, etc. to catch nutrients and chemicals.

Windbreaks: the trees offer wind protection up to a distance of about 10 times their height, offering benefits to horticulture operations.

Silvopasture: requires management of livestock to avoid damage to the trees, overgrazing, and soil compaction.

Technical requirements

Generally, all crop systems can be adapted to agroforestry systems. Tree density must be adapted to the crops' shadow requirements. More productive systems (e.g., conifers, short rotations) have a higher nutrient uptake, which can be maintained by regular harvesting. For afforested arable land, additional measures to increase soil aeration and improve soil structure might be necessary.

Effects, benefits and costs

Benefits for farming business Cost-savings from applying less mineral fertiliser when simultaneous grazing is adopted; more shade can potentially decrease the need for irrigation; increased soil fertility and water retention due to higher soil organic matter content (e.g., leaf litter increasing above-ground biomass).

Costs for farming business Initial investment costs; long amortisation period before the trees mature and provide the expected benefits; loss of production surface for the herbaceous crop.

Co-benefits and trade-offs Trees store precipitation on leaf and trunk surfaces before draining off and infiltrating into the soil for increased groundwater replenishment and decreased risk of flooding. To avoid water competition between trees and crops, small-scale broadleaves should ideally be planted. The mixed cropping between horticulture and fruit trees could also prevent the nutrient loss experienced due to the shallow root depth of the former crop and increase nutrient efficiency. Due to the soil cover, soil erosion is reduced and therefore phosphorus loss is reduced.

Environmental effects

Soil: Improved soil fertility and structure, water retention capacity, and soil biodiversity through increased soil organic matter and reduced risk of soil erosion, contributing to carbon sequestration and storage in the soil.

Water: Reduced risk of leaching and run-off of nutrients (P, N and K) by increasing plant uptake and root retention, decreasing eutrophication and improving surface and groundwater quality, thereby lowering risks to human health and biodiversity

Biodiversity: Agro-forestry increases on-farm agro-biodiversity through introduction of new plant species and below-ground fauna.

Further good practices to reduce nutrient losses

Reducing the amount of nutrients produced by adapting feeding techniques

Feeding practices can decrease the amount of nutrients excreted by livestock. The options are to (a) adjust the feed (and hence the nutrients) to the animals' needs or (b) increase the assimilation of nutrients by the animals. Adjusting the amount of feed provided requires farmers to calculate the nutritional needs of their animals and have information on the nutrient composition of the feed. In order to facilitate diversified feeding, animals can be grouped by gender and by age or production stage. This measure reduces feed waste and prevents excessive amounts of feed from being ingested by the animals. Increasing the assimilation of feed by animals requires increasing the digestibility of the feed provided, i.e., by processing the feed or adding phytase or amino acids. The farmer can also decrease the protein content of the feed, which is very effective in reducing the amount of nutrients excreted.

Improving fertiliser application techniques

Ammonia is emitted when manure is spread. Band spreading using a trailing hose and trailing shoe results in a reduction of ammonia emissions by 30% (on short grass) and 60% (on tall grass). Similarly, deep injection results in more than a 90% reduction in ammonia emissions. The incorporation of manure once it has been spread also limits ammonia volatilisation. Incorporation of slurry by ploughing within 6 hours after its application could reduce ammonia emissions by as much as 60%. When fertiliser is incorporated immediately after spreading or directly injected into the soil, less nutrient run-off may result. As 27% of the holdings in Spain do not immediately incorporate solid manure or slurry after application, the potential for improvement is relatively high.

Improving irrigation management and re-using agricultural drainage water

The re-use of agricultural drainage water for irrigation entails pumping lost irrigation water from drainage channels and re-injecting this water into the irrigation cycle. The drainage water has high nutrient levels as a result of leaching and run-off. To ensure that the measure is highly effective, it is important to monitor the exact concentration of nutrients in the drainage water in order to adapt additional fertiliser input and to avoid exceeding the crop N requirements as well as salinisation of the soil. Several pilot studies have been hosted in the country, which showed good results and lessons learned from which future uptake of this practice can benefit. (7)

Retaining nutrients in constructed wetlands

Constructed wetlands could help capture the nutrients contained in drainage water or run-off before it reaches water bodies. This measure provides a simple, low-cost and low-maintenance option for avoiding nutrient losses. Studies have demonstrated that this technique is appropriate for arid areas such as the Murcia region, where between 51 to 91% of N was removed by wetlands based on their location and type (e.g., surface or subsurface wetland). (8) Wetlands can also have positive climate benefits as carbon sinks, though wetlands may naturally release methane. Disturbance of their water table levels through drainage, for instance, may also result in high nitrous oxide emissions. Constructed wetlands are mostly suitable for small- and medium-sized pig farms since large farms produce an excess of slurry that needs to be processed in a short period of time. The remaining solid components which settle and are separated from the liquid fraction in the wetlands may have a high salt content, so they should not be used continuously as a fertiliser in order to avoid soil and plant salinisation.



Further relevant links

Further information (links) on the issue of reducing nutrient losses in agriculture which are relevant for the Murcia region can be found below. This information entails links to legal documents, initiatives, institutions and studies.

EU level

DG Environment - Nitrates Directive:

http://ec.europa.eu/environment/water/water-nitrates/index_en.html

The study "Resource Efficiency in Practice - Closing Mineral Cycles" is available at the following link:

<http://ec.europa.eu/environment/water/water-nitrates/studies.html>

DG Environment - Sustainable use of phosphorus:

<http://ec.europa.eu/environment/natres/phosphorus.htm>

Contacts:

ENV-NITRATES@ec.europa.eu;

ENV-USE-OF-PHOSPHORUS@ec.europa.eu

National and regional level

Sistema de Información Agraria de Murcia (SIAM) (Agricultural Information System of Murcia):

<http://siam.imida.es>

Consejo de Agricultura Ecológica de la Región de Murcia (Council of Ecological Agriculture of the Murcia Region):

<http://caermurcia.com/presentacion/>

Studies and projects

LIFE project "Aquemfree" (reducing contamination in residential drinking water through use of solar power):

<http://www.life-aquemfree.eu/>

Gómez-Garrido, M. et al. (2014) Soil fertility status and nutrients provided to spring barley (*Hordeum distichon* L.) by pig slurry.

Idassi, J.O. (2012) Profitable Farms and Woodlands: A Practical Guide in Agroforestry for Landowners, Farmers and Ranchers.

Región de Murcia, Consejería de Agricultura y Agua, La fertirrigación del limonero (Murcia Region, Council of Agriculture and Water - Lemon Tree Fertigation):

<http://frutales.files.wordpress.com/2011/01/cit-04-1196-la-fertirrigacion3b3n-en-el-limonero-1.pdf>

Castilla-La Mancha (2005) Fertirrigación (Fertigation):

<http://crea.uclm.es/siar/publicaciones/files/HOJA11.pdf>

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Cover page: Almond trees blossom in the region of Murcia © Carmen sedano / Alamy - P3: Jellyfish (*Cotilorhiza tuberculata*) caught in the jellyfish net inside the bathing area in Mar Menor © José Navarro Leandro/www.marmenorenclave.blogspot.com - P6 top: Drip irrigation to reduce water use and nutrient losses, here for melon production © age fotostock / Alamy - P6 bottom: Suckling pigs on a modern hog breeding farm © Greg Taylor / Alamy - P8: The volatilisation of ammonia from manure can be reduced by acidifying slurry using sulfuric acid, which may take place either in the stable, slurry tank or during field application © Mette S. Carter, DTU - P9: Floating cover for slurry ponds (hexagonal polypropylene pieces) Hexacover in a slurry tank © Aguilar M, Abaigar A, Irujo E, Calvet S, Merino P, 2012. "Performance of floating covers for slurry storage in Northern Spain". Paper No 0955. Proc. Int Conf Agric Eng CIGR-AgEng 2012. Valencia (Spain). - P10: Slurry separation enables export of the phosphorus-rich solid fraction to non-livestock farms, where this nutrient is utilised more efficiently in plant production © Frank Bondgaard / VFL - P11: Farmer taking soil samples out of ploughed field. Matching crop requirements and nutrient content of soil and fertilisers can minimize nutrients losses and reduce expenses © Wayne Hatchinson / Alamy - P12: Composting is a natural process that transforms manure into a valuable organic fertiliser which is easier to handle and transport than fresh manure © Jennifer Moreno Cornejo - P13: Agroforestry in orchards would increase the capture of nutrients and water by root systems © AGROOF

Project:

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