A low environmental impact system for beef cattle manure distribution on maize

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Abstract

An experiment was carried out in order to evaluate the applicability of a new technique for managing and distributing beef cattle manure during irrigation on maize when the crop is present in order to reduce the negative effects on air and water quality. Traditional manure distribution system was compared with a low impact management system using a side-move travelling system for the distribution of wastes (liquid separated) mixed with irrigation water (fertigation) on the soil surface. The first results show that the use of the new technique reduces the emissions of ammonia in the air and consequently the diffusion of bad odours in the atmosphere, with positive consequences for the local population. Provisional results of leaching water samples seem to indicate that also the percolation water quality is better due to a reduction in nitrate nitrogen losses.

Keywords: Side-Move irrigation system, LEPA, manure distribution, low environmental impact.

Introduction

The use of livestock wastes through agricultural irrigation systems has a potential positive impact on the environment, both reducing odours and seepage into groundwater and decreasing fertiliser use. The traditional distribution of livestock wastes is a cause for concern due to environmental issues and complaints of the local population, particularly if not directly involved in agricultural activities.

The most evident negative effect is given by nitrogen losses in the environment, since this element is usually applied in big amounts, as crop response to it tends to be major, and it is easily leached due to the high solubility of its nitrate form, not held by soil colloids.

Nitrogen losses may result in water bodies eutrophication, a process that causes algal and plant eccessive growth and the eventual death of most organisms living in lakes, ponds, estuaries or slow streams and rivers. In order to reduce the impact of this phaenomenon it is important to maximise nitrogen crop interception, and therefore to distribute fertilisers when crops need them and apply them in correct amounts. This may not be always possible, due to manure tanks dimensions that may require manure removal and use in different times of the year (Berti et al., 2006); further, after a certain crop development stage it is not possible to apply manure with the traditional fertilisation systems.

As for gas emissions, the expansion of urbanised areas in traditionally rural locations reduced the distance between residential and agricultural zones, causing clashes like those due to bad odours diffusion from livestock farms and during manure and slurry field distribution. Bad odours, even though they are not a source of toxicologic problems (Valli, 2001), are still associated by people with a scarce environmental healthiness; further, ammonia emissions are often connected to bad odours diffusion. This is particularly important as agriculture is responsible for 90% of ammonium nitrogen emissions into the atmosphere (Balsari and

Gioielli, 2003), a key factor in acid rain formation.

The use of livestock wastes in the high Veneto plain (Northern Italy), where soils tend to be rich in stones and gravel, thin (not more than 50 cm of depth) and therefore have a low water retention capacity, is problematic. Livestock farming in the area is widespread and it produces big amounts of manure that need to be disposed of, possibly incorporating them immediately after field distribution. Manure is usually applied in spring and in autumn, when rainfall is more abundant; summer application, which would favour nutrient mineralisation and plant uptake in a key period, is usually not possible as forage crops (mostly maize) are present in the field.

Irrigation is also an issue in this area, as maize cultivation would not be feasible without it, due to soil characteristics, but at the same time environmental risks are present: with sprinkler irrigation on average only 43% reaches directly the soil surface with a 20 cm in row spacing, while most of the rest is intercepted by the leaves and flows along the culm, concentrating at the bottom of the plant (Lamm and Manges, 2000). This is a probable cause for deep leaching and decreased irrigation efficiency; distributing water directly to the soil, under the canopy, would reduce this type of losses and therefore irrigation volumes could be smaller, still allowing sufficient forage productions for cattle feeding.

An experiment was carried out in order to evaluate the applicability of a new technique for managing and distributing beef cattle manure during irrigation on maize when the crop is present. The project aim is a comparison between a traditional manure distribution system and a low impact management system using a side-move travelling system for the distribution of wastes (liquid separated) mixed with irrigation water (fertigation) on the soil surface.

Material and methods

The experiment was started in June 2006 and it is still in progress. The experimental field (figure 1) is located in the high alluvial plain of the Veneto region (NE Italy) and is 2.2 ha, divided in two parts: the side-move system is used on an area 25 m wide and 160 m long, whereas in the remaining part a solid set irrigation system is installed and livestock wastes are

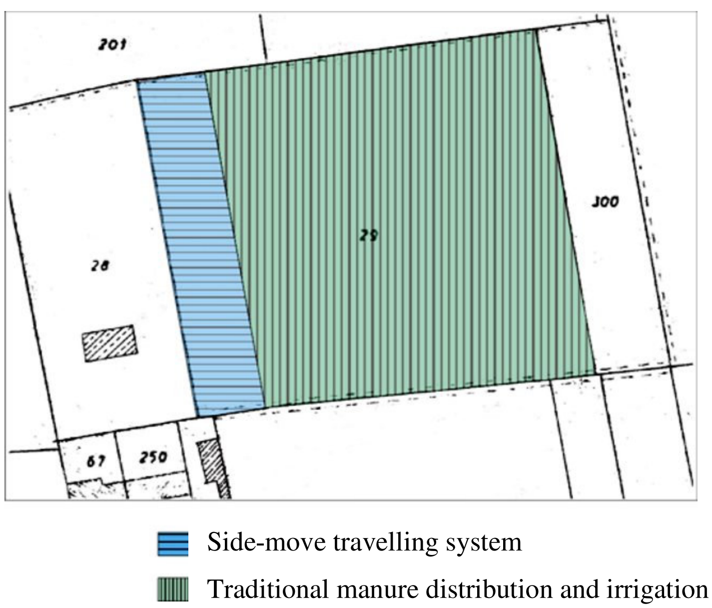

Figure 1. The two parts of the experimental field (NE Italy)

applied separately using a tank wagon equipped with splash plate. The location was chosen for its environmental importance, as it is situated inside the Venice Lagoon Watershed, and for the large diffusion both of maize cultivation and beef cattles which are one of the major cause of nitrate pollution of water in this area.

According to the de Martonne index calculated for the decade 1994-2003, the climate in the area is humid to perhumid, while soil type is alfic udarents loamy-skeletal, mixed, non acid mesic soils according to the USDA classification.

For the irrigation and fertigation (distribution of the liquid separated portion mixed with irrigation water) the boom of the hose-reel machine was equipped with drop tubes, similar to a LEPA system (Lyle and Bordowsky, 1981), to apply water directly on the soil surface under the canopy without leaf interception (figure 2 and 3) (Lamm et al., 2006).


Figures 2 and 3. The hose-reel machine and the boom equipped with the drop tubes

The manure was initially treated with a mechanical separator and injected before the turbine of the hose-reel machine by means of a Venturi injector. The separator did not give the expected results, due to the eccessive quantity of suspended solids (mostly hay and fiber) in the liquid separated portion that blocked the holes of the hose-reel machine almost immediately. To overcome the problem, from May 2008 a new mechanical separator (figure 4) was installed and successfully used.

Figure 4. Separation of manure in liquid and solid portions with mechanical separator

From June 2007 leaching water samples were periodically taken with lysimeters to measure the content of nitrate nitrogen in percolation water, in order to evaluate the differences between the two thesis. These instruments did not prove to be reliable, possibly because of the scarcity of leaching water or of the characteristics of the soil. As a result, in 2008 also four water-catching metal plates (figure 5) were installed about 30 cm below the soil surface to collect leaching water samples; these new tools allowed collecting and analysing samples frequently during the season.

Figure 5. Water catching plate and flask for leaching water sample collection

During wastes application, air was monitored to evaluate the presence of bad odours with an instrument (figure 6) designed and built at the Agricultural Mechanisation Laboratory of the University of Padova. It consists of a Plexiglas tunnel and a fan to maintain temperature and humidity conditions similar to those outside; the air is sucked in by a pump through a small plastic pipe that contains a phial indicating the amount of ammonia in the air. This survey was carried out both when traditional manure and liquid separated distribution were taking place in order to compare the effects of the two systems.

Figure 6. Tool for the measurement of ammonia emissions

Manure, liquid and solid separated portions of manure, liquid and muddy filtered portions of manure were analysed in the following parameters: total nitrogen, ammonium nitrogen, phosphorous, potassium, suspended solids, humidity.

Results

In 2007 the two systems could not be compared, due to the malfunctioning of the mechanical separator. As a consequence, the portion of the field that should have received organic nitrogen along with irrigation lacked a considerable part of fertilisation; nevertheless, it is interesting to notice that at the end of the season the yield in the two parts of the field was almost identical: 8,95 t/ha for the traditionally managed maize and 8,93 t/ha in the experimental part. This indicates a probable excess in the amount of nitrogen usually distributed to the crop by the farmer.

The very scarce amount of water samples collected in 2007 did not allow to draw any conclusion concerning leaching water quality; however, it may still be pointed out that the highest concentrations of nitrate nitrogen (more than 330 mg/L and 80 mg/L) were found in the traditionally managed portion, whereas almost all the samples collected in the other part had a very low content of nitrate nitrogen.

As for 2008, the delay in fertigation due to the problems in finding the adequate separating machine caused a late distribution of nitrogen with the boom, which resulted in an obvious difference of growth speed between the two thesis in the first part of the season. Naturally, this will have to be taken in to account at the harvest.

Leaching water samples that have been analysed so far seem to indicate that nitrate nitrogen concentrations are higher in the traditionally managed part of the field (figure 7), with an average of 62 mg/L compared to an average of 33 mg/L, even though further investigation is necessary to reach more precise conclusions.

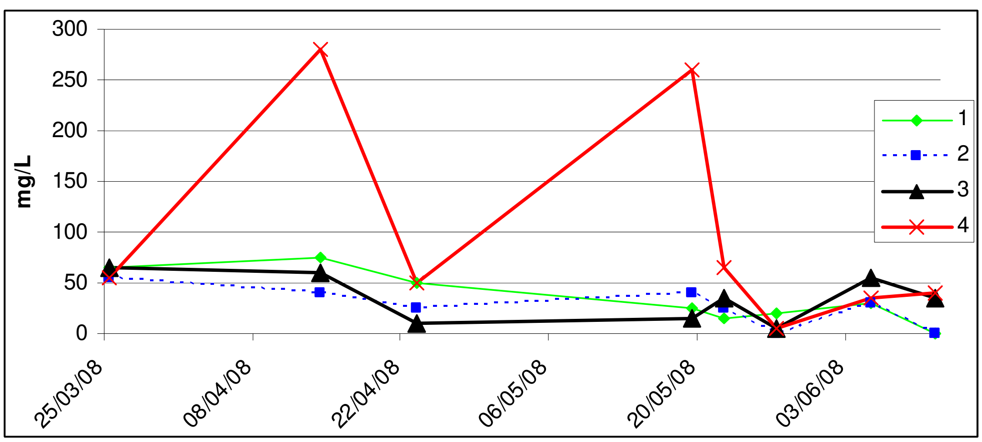

Figure 7. Nitrate nitrogen in leaching water collected from catching plates in 2008 (numbers 3 and 4 are located in the traditional manure distribution portion)

As regards the ammonia emissions, the measurements showed that the amount of ammonium nitrogen lost in the environment, and therefore the level of bad odours, is higher with the traditional system than in the case of the summer distribution of the liquid portion of manure, even though the application takes place in March with lower temperatures. Actually, placing the instrument near the distributing tank wagon four 30 ppm phials were consumed in about 90 minutes, especially due to spray effect occurring at the moment of manure distribution; after the end of the application, 80 and 90 minutes were necessary to consume a 30 ppm phial in two different surveys that took place in March 2007 and March 2008, with a temperature of 18 °C and 16 °C respectively. On the other hand, placing the instrument near the distributing boom in July, when a temperature of about 30 °C favours ammonia volatilisation, about 150 minutes were necessary to consume a 30 ppm phial: concentration of ammonia were almost half while fertigation was carried out.

Conclusions

The first results show that the use of the new technique reduces the emissions of ammonia in the air and consequently the diffusion of bad odours in the atmosphere, with positive consequences for the local population.
Provisional results of leaching water samples seem to indicate that with the innovative technique also percolation water quality is better due to a reduction in nitrate nitrogen losses.

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