Use of drip lines for the application of the liquid fraction of digested pig slurry on maize

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Abstract

The effects on production and the environment of the application of drip lines technology to distribute the liquid fraction of digested pig slurry on maize, mixing it with irrigation water, have been compared with those of the more traditional technique of band-spreading of untreated pig slurry at the first growing stages of the crop (also irrigated by means of drip lines).

There was clearly a more efficient use of the nitrogen when the liquid fraction of the digested slurry was used; higher uptake levels (290 kg N ha^{-1}) were measured as compared with the amounts provided by chemical fertilisers and slurry (272 kg N ha^{-1}).

With reference to nitrogen losses into the atmosphere, the technique demonstrated significant environmental benefits with a reduction of more than 90% in ammonia emissions as against the reference system.

Over the cultivation period (particularly in July) significantly higher nitrate concentrations were detected in the soil and soil water where the liquid fraction of digested pig slurry was distributed (average values > 100 mg $N\text{-}NO_3$ l^{-1} of soil water). Considering however, the low rainfall over the summer and the presence of a growing crop, the nitrate concentrations measured in the soil (also decreasing from the surface to the depth of 50 cm and from July to the end of the summer) were not such as to give a greater risk of nitrogen leaching.

Keywords: ammonia, anaerobic digestion, crops, nitrate, N use efficiency, soil, uptake.

Introduction

Anaerobically digested slurries maintain almost the same total nitrogen quantity as unprocessed materials, with organic N largely converted into ammonia N which can be assimilated easily by crops. The solid/liquid separation of digested slurry concentrates ammonia nitrogen in the liquid fraction and the organic matter in the solid fraction.

The liquid fraction develops characteristics which can thus be compared to those of a chemical fertiliser solution. It can be hence possible to obtain N use efficiency values significantly greater than those normally achievable from unprocessed slurry.

With the aim of maximising the N use efficiency, the liquid fraction of digested pig slurry obtained by means of sedimentation was used for the fertilisation of grain maize, distributing it by means of drip lines and mixing it with irrigation water prior to pumping.

Materials and methods

The effects on production and the environment of the application of drip lines technology to distribute the liquid fraction of digested pig slurry, mixing it with irrigation water (to be referred to as “water/digested slurry mixture”), have been compared with those of the more traditional technique of band-spreading of untreated pig slurry at the first growing stages of the maize crop (to be referred to as “untreated slurry”, it too, irrigated by means of drip lines).

The liquid fraction was used on a neutral not calcareous silt loam soil in Montechiarugolo (Parma, Northern Italy) for the fertilisation of grain maize, with a drip line serving two rows of plants contemporaneously; the rows were 0.7 m apart from each other, each drip line was positioned between alternate rows and thus 1.4 m from each other. The drip line system was fed by a pump supplying a mixture of about one part slurry to three parts water. There was a filtering unit immediately after the pump designed to reduce the risk of occlusions in the labyrinth of drippers on the drip lines (one every 30 cm). The drip-line supply-side pressure was 1 bar with each drip line about 150 m in length. The flows measured ranged between 2.5 and 3.0 l m^{-1} $hour^{-1}$.

Table 1 sets out the time table followed for distribution of irrigation water alone or the water/slurry mixture. It should be noted that the water/slurry mixture supply was always followed by an hour of water alone in order to wash the drip lines and to complete the irrigation water supply. In the treatment with band spreading of untreated pig slurry at the crop's first growing stages exactly the same irrigation volumes were supplied on the same days. Table 2 shows the average chemical characteristics of the water/slurry mixture.

Table 1. Time table followed for irrigation/fertilisation

Date	Operation	Duration (hours)	Operation	Duration (hours)
12 June	Water with insecticide	4	-	-
16 June	Water+slurry	3	Water	1
23 June	Water+slurry	3	Water	1
24 June	Water	4	-	
25 June	Water	4	-	
30 June	Water+slurry	3	Water	1
1 July	Water	4	-	
2 July	Water	4	-	
7 July	Water+slurry	3	Water	1

Table 2. Average chemical characteristics of the water/slurry mixture

Parameters	Unit of measure	Average value
pH	-	8.2
Total solids	g kg^{-1}	3.1
Total suspended solids	g l^{-1}	0.27
Volatile solids	g kg^{-1}	0.81
Total Kjeldahl nitrogen (TKN)	mg kg^{-1}	627
Ammonia nitrogen	mg kg^{-1}	540
	% TKN	86

Nitrate concentrations were checked in samples of both soil and soil water taken from depths of up to 50 cm under the drip lines. Measurements were also made of the ammonia emissions into the atmosphere following the application of the slurry, using specially designed mini wind tunnels. Determination of the maize nitrogen uptake and the "Nitrate stalk testing" (End-of-season corn stalk test, Fox *et al*., 2001; Wilhelm *et al*., 2000) were also carried out at the maize harvest (15th September) in order to establish the nitrogen availability for the crop.

Results and discussion

There was clearly a more efficient use of the nitrogen when the water/slurry mixture was used and higher uptake levels were measured as compared with the amounts provided by chemical fertilisers and slurry (Table 3). The effect can be explained by the great precision in the delivery of the nitrogen to the crop at times when the element is most adsorbed by the plant. This is shown by the concentrations of nitrogen and nitrates in the harvested maize, significantly higher in the treatment with the mixture of water and liquid fraction of digested slurry (Table 4 and 5).

Table 3. Nitrogen inputs and outputs for the two treatments

	Water/digested slurry mixture	Untreated slurry
Input from mineral fertiliser	78	78
Input from slurry	194	245
Total input	272	323
Maize uptake (epigeal part)	290	247
Inputs-Outputs	-18	76

Table 4. Nitrogen concentrations in maize tissues (% of DM)

	Water/digested slurry mixture	Untreated slurry	Significance[1]
Grains	1.73	1.62	**
Cobs	0.31	0.28	n.s.
Stalks	1.13	0.84	***

[1] n.s., *, **, *** differences between means not significant, significant at P<0.05, 0.01 and 0.001, respectively, according to ANOVA.

Table 5. "Nitrate stalk testing" (End-of-season corn stalk test) results

	Water/digested slurry mixture	Untreated slurry
NO_3-N (mg DM kg^{-1})	4182	781
Valuation[1]	Excessive	Optimal

[1] <200 insufficient, 200<700 low, 700<2000 optimal, >2000 excessive

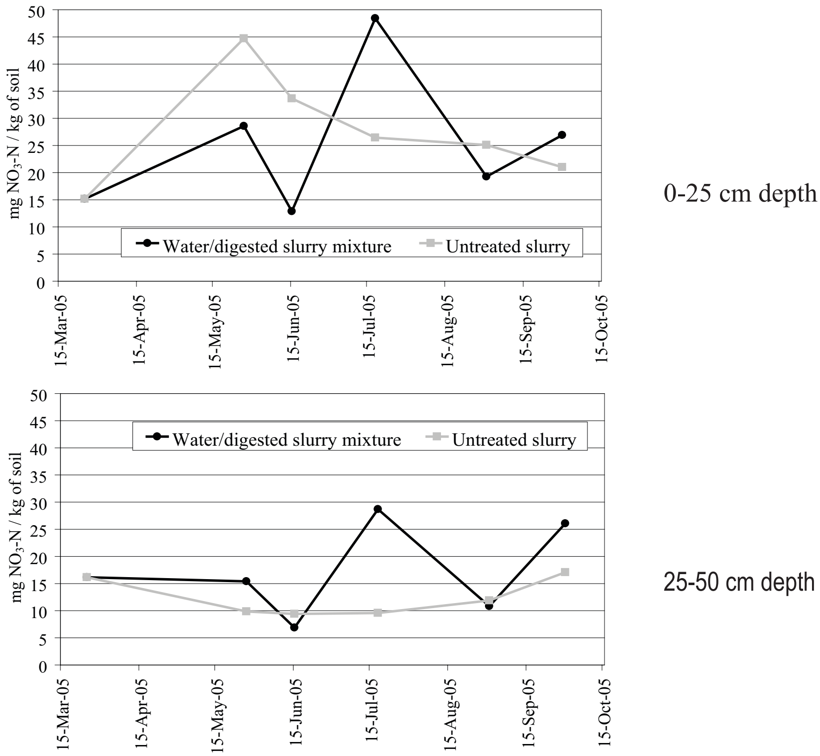
With reference to nitrogen losses into the atmosphere, the drip lines technique demonstrated significant environmental benefits with a reduction of more than 90% in ammonia emissions as against the reference system (Table 6). This can be attributed to the possibility of supplying nitrogen over an extremely long time-frame with respect to the traditional application techniques (total of 12 hours to distribute about 200 kg N ha^{-1}); it was also due to the high level of dilution and the washing of the drip lines with just water following the fertilisation.

Table 6. Ammonia emissions from the different treatments

Emissions	Water/digested slurry mixture	Untreated slurry
% of applied TKN	1.15	12.2
% of applied NH4-N	1.35	17.2
kg N ha-1 (emitted)	2.2	30.3

Over the cultivation period (particularly in July) significantly higher nitrate concentrations were detected in the soil and soil water where the liquid fraction of digested pig slurry was distributed (average values > 100 mg N-NO_3 l^{-1} of soil water). Considering however, the low rainfall over the summer and the presence of a growing crop, the nitrate concentrations measured in the soil (also decreasing from the surface to the depth of 50 cm, Figure 1) were not such as to give greater risk of nitrogen leaching.

Figure 1. Nitrate nitrogen concentrations measured in the soil at two different depths



Conclusions

It can be concluded that the drip lines technique represents a solution capable of maximising the use efficiency of the distributed nitrogen. The drawbacks remain in the operational implementation of the technique, requiring the setting up of the distribution equipment, its removal at the end of the cultivation, rodent control and the maintenance of the pumping and filtering system.

The filter maintenance was fairly efficient provided that the slurry was pumped taking care to extract it from the upper layers of the storage tanks. A precise cost assessment remains to be effected.

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