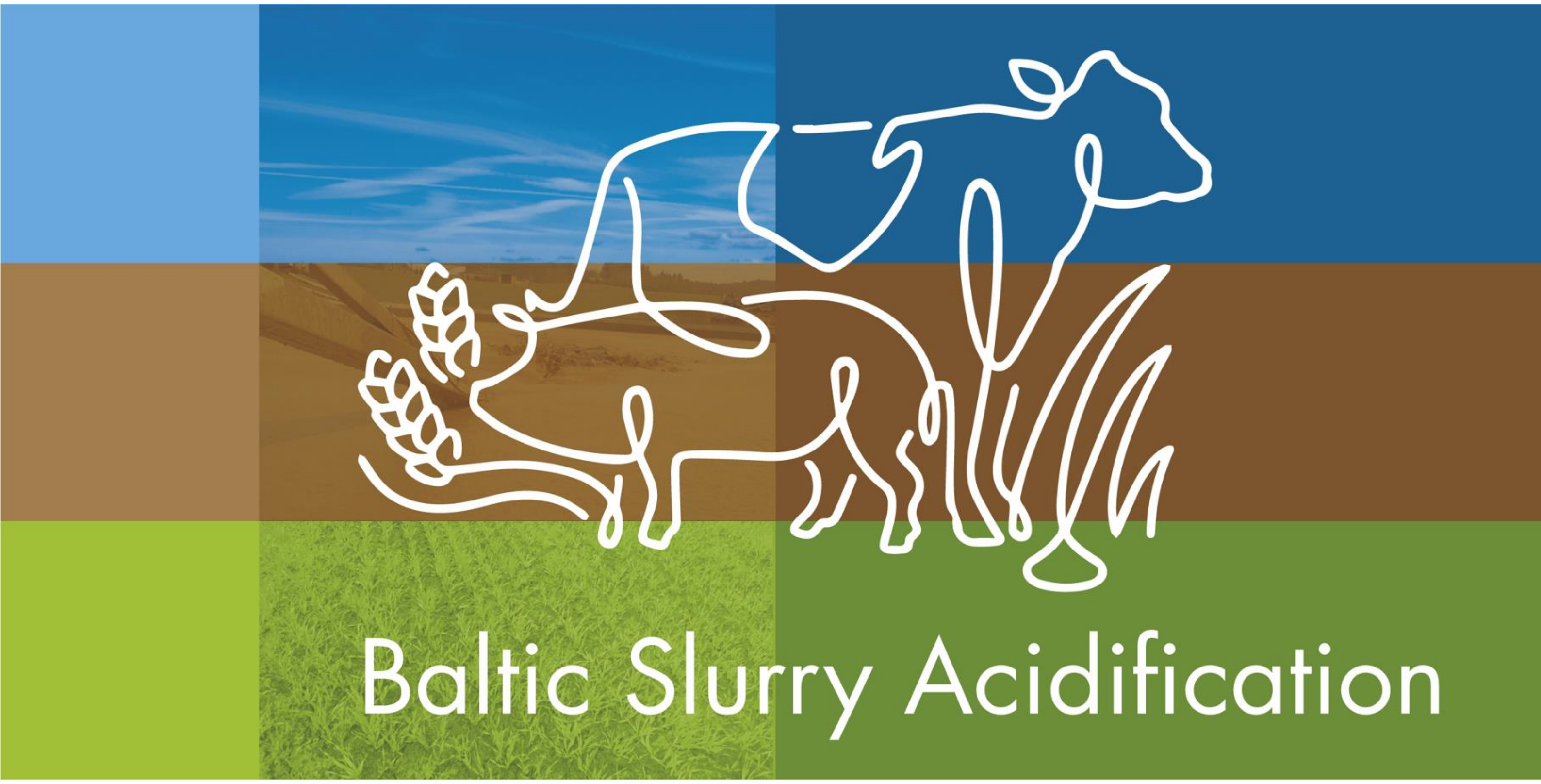

Guidelines and recommendations

of slurry acidification techniques (SAT) in field

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Interreg
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Baltic Slurry Acidification

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Summary

Acidification of slurry can be used to reduce ammonia emissions. The reduction in ammonia emissions can be 40 – 70 % when the pH is lowered to pH value 6. This can mean 10 – 20 kg nitrogen (N) saved per hectare. Analysis of slurry pH is important because acidification has the largest benefits when used in slurries with pH 7 or more. The weather conditions during the spreading also have a significant impact on ammonia emissions. The risk of ammonia emissions is much bigger on a sunny, windy and warm day than on a calm and cool day.

The use of acidified slurry resulted in similar or higher yields compared to untreated slurry but the yield difference was not statistically significant. No damages to the crops could be observed and the growth of plants as well as the yield and quality formation was normal. Acidification may improve the nitrogen availability to plants, but the benefit varies from year to year and is much dependent on the weather conditions during the growing season. Also, the nitrogen status of the soil affects the N use efficiency of the crop. In acidified slurry, the increased sulphur content may also have positive yield impacts especially in cases where shortage of this plant nutrient occurs. Acidification of slurry with sulphuric acid can bring approximately 30 – 40 kg S per hectare. The cost efficiency of slurry acidification techniques is dependent on the yield impact contra the extra costs caused by sulphuric acid treatments and equipments.

Slurry acidification techniques can be used as alternative methods under conditions where risks of ammonia emissions are big. Acidification can, thus, be regarded as one tool for farmers to mitigate ammonia emissions when spreading conditions are unfavorable.

The results and recommendations written in this report are based entirely on the experiences obtained in the Baltic Slurry Acidification project over a period of 1 to 3 years in 2016-2018. It should be noted that the weather conditions during the trials were extreme in all countries where the trials were performed: extreme wet and cool in 2017 and extreme dry and hot in 2018.

Guidelines and recommendations

Appropriate pH value of slurry and the corresponding acid demand

The pH of different animal slurries varies from pH 6 to 9 depending e.g. by feeding or litter used but is usually close to pH 7. The pH of the digestion residue of biogas production is higher, pH 8. Decreasing the pH reduces ammonia emissions by keeping the ammonia (NH_3) in ammonium form (NH_4^+) which does not evaporate. The target pH level is pH 6,0 – 6,4 when ammonia emissions are decreased remarkably. Therefore, analysis of slurry pH is important. Slurries with pH 7 or more are most appropriate for acidification.

Usually high concentrate, 95 – 97 %, of sulphuric acid is used for slurry acidification. The amount of sulphuric acid used for acidification can, thus, be 1 to 5 liters per ton of slurry depending on the treatment technique and the starting pH of the slurry. The slurry has the capacity to buffer the pH towards the original level very soon after the acid is added. Therefore, the sooner the slurry is spread after acidification the less acid is consumed in total. Adding acid to slurry can cause foaming.

When using sulphuric acid it should be noted that it is strong acid which should be handled with extreme care and proper protective clothes must be used. When mixed with slurry the acid is diluted and its harmfulness is reduced remarkably. One option for carrying out acidification could be contracting.

Benefits of SAT for fertilization rates

Acidification increases the potential nutritional value of the slurry. The amount of nitrogen saved can be 10 – 20 kg N per hectare. The benefit of nitrogen utilization varies from year to year depending on the weather conditions in the growing season and the nutrient status and the amount of organic matter in the soil.

Acidification of the slurry with sulphuric acid brings sulphur to the crop. The amount of sulphur available for crops varies according to the amount acid used to acidify slurry. For example, 2 liters of sulphuric acid used for 30 ton of slurry per hectare brings 34 kg S per hectare. Also, the soluble phosphorus of slurry can increase when acidified. Use of acidified slurry can reduce the pH level of the soil but the reduction is not necessarily different from that caused by normal fertilization practices.

Benefits of slurry acidification on yield formation

Slurry acidification can benefit crop growth and yield formation. This is due to reduction in ammonia emissions which makes more nitrogen available for plants. Yield responses are however not always clear, and they can vary depending on the growing season. Also, the nitrogen status of the soil affects the N use efficiency of the crop.

In the field trials carried out in the Baltic Slurry Acidification project, acidification of slurry resulted in similar or higher yields compared to fertilization with untreated slurry. The measured yield differences were not statistically significant. No damages to the crops were observed and the growth of plants as well as the yield and quality formation was normal.

The cost efficiency of slurry acidification techniques is dependent on the yield impact contra the extra costs caused by sulphuric acid treatments and equipments. The slurry incorpartion immediately after application is not required if slurry is acidified. Also, the working efficiency of spreading techniques affects the results. Acidification allows the use of surface spreading techniques which have clearly wider working widths than e.g. injection. Acidified slurry is appropriate to be used in fields with growing plants where tillage is not possible. Moreover, when slurry is used in growing season, temperature is usually favourable for ammonia emissions which makes acidification environmentally sound and profitable.

Checklist for slurry acidification in field

1. Measure the pH of the slurry
    - slurry with pH 7 or more has significant risk for ammonia emissions during surface spreading
2. Estimate the risk for ammonia emissions based on weather conditions
    - if spreading conditions are favorable for ammonia emissions (sunny, warm, windy), use acidification in surface spreading (trailing hose)
3. Use appropriate amount of acid to lower the pH value. Target pH level 6 – 6,4 at spreading is enough
    - handle acid with extreme care or ask contractors!
4. Take sulphur into account in fertilization rates when using sulphuric acid
    - acidification brings approximately 30 – 40 kg S per hectare
    - check the crop needs of sulphur
    - adjust the use of acidified slurry with mineral fertilization, because excess of sulphur may cause leaching or competition with calcium
5. Follow the crop growth
    - acidification does not cause damages to the crops: the growth of plants and the yield and quality formation is normal
    - reduction in ammonia emissions makes more nitrogen available for plants but yield responses are not always clear

The results and recommendations written in this report are based entirely on the experiences obtained in the Baltic Slurry Acidification project over a period of 1 to 3 years in 2016-2018. It should be noted that the weather conditions during the trials were extreme in all countries where the trials were performed: extreme wet and cool in 2017 and extreme dry and hot in 2018.

Annexes

Summary of field trials in Estonia

Estonia				
Year	2017		2018	
Plant	Winter wheat	Grassland	Winter wheat	Grassland
Slurry	Pig	Cattle	Pig	Cattle
SAT type	In-storage	In-storage	In-storage	In-storage
Used amount of sulphuric acid (l / tn slurry)	2,465	5,14	6,3	1,2
Slurry pH before acidification	7.6	7.9	8.2	7.9
Slurry pH after acidification	6.3	5.0	7.2	6.9
Soil pH before field trial	7.1	6.7	7.25	6.39
Soil pH after field trial	7.1	6.5	7.16	6.35
Amount of spread slurry (m^3/ha)	48	30,4	29,3	43,3
Amount of S (kg/ha) to the field with untreated slurry	1	10,6	9,3	12,1
Amount of S (kg/ha) to the field with acidified slurry	52,8	78,1	89,9	43,3
Change in yield due to acidification	About 250 kg/ha better yield with acidified slurry compared to untreated slurry and mineral fertilizer.	About 120 kg/ha lower yield with acidified slurry compared to untreated slurry and about 650 kg/ha lower compared to mineral fertilizer	Almost exactly the same yield between all treatments (acidified slurry, untreated slurry and mineral fertilizer).	About 150 kg/ha better yield with acidified slurry compared to untreated slurry but about 100 kg/ha lower yield compared to mineral fertilizer.
Results of statistical analysis of the yield	No significant difference between untreated slurry, acidified slurry and mineral fertilizer	No significant difference between untreated and acidified slurry, but the yield of mineral fertilizer was significantly better than acidified slurry yield.	No significant difference between untreated slurry, acidified slurry and mineral fertilizer.	No significantly different yield with acidified slurry compared to untreated slurry or mineral fertilizer.
Ammonia emission measurements	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done

Summary of field trials in Finland

Finland		
Year	2017	2018
Plant	Spring wheat	Spring wheat
Slurry	Pig	Pig
SAT type	In-field	In-field
Used amount of sulphuric acid (l / tn slurry)	3,25	3,225
Slurry pH before acidification	7.0	6.9
Slurry pH after acidification	6.0	6.1
Soil pH before field trial	5.9	5.9
Soil pH after field trial	Not measured	Not measured
Amount of spread slurry (m^3/ha)	12,5	13,8
Amount of S (kg/ha) to the field with untreated slurry	3,4	1
Amount of S (kg/ha) to the field with acidified slurry	27,5	29
Change in yield due to acidification	About 300 kg/ha better yield with acidified slurry compared to untreated slurry and under 100 kg/ha better yield compared to mineral fertilizer.	Less than 30 kg/ha difference between untreated and acidified slurry, almost 300 kg/ha better yield with acidified slurry compared to mineral fertilizer.
Results of statistical analysis of the yield	No significant difference between untreated slurry, acidified slurry and mineral fertilizer	No significant difference between untreated slurry, acidified slurry and mineral fertilizer
Ammonia emission measurements	No ammonia emission measurements done	No ammonia emission measurements done

Summary of field trials in Germany

Germany				
Year	2017		2018	
Plant	Winter wheat	Grassland	Winter wheat	Grassland
Slurry	Digestate	Digestate	Digestate	Digestate
SAT type	In-field	In-field	In-field	In-field
Used amount of sulphuric acid (l / tn slurry)	45,5 (10% acid)	45,5 (10% acid)	45,5 (10% acid)	45,5 (10% acid)
Slurry pH before acidification	8.7	8.7	8.3	8,3
Slurry pH after acidification	5.5	5.5	5.9	5,9
Soil pH before field trial	5.4	5.3	5.4	5.34
Soil pH after field trial	Not measured	Not measured	Not measured	Not measured
Amount of spread slurry (m^3/ha)	47	56	53	64,8
Amount of S (kg/ha) to the field with untreated slurry	75,2	89,6	84,8	103,68
Amount of S (kg/ha) to the field with acidified slurry	75,2	89,6	84,8	103,68
Change in yield due to acidification	2 t DM/ha	1,9 t DM/ha	1,2 t DM/ha	3,1 t DM/ha
Results of statistical analysis of the yield	Yield was significantly higher with acidified digestate compared to untreated digestate	No significant difference between acidified and untreated digestate	No significant difference between acidified and untreated digestate	Yield was significantly higher with acidified digestate compared to untreated digestate
Ammonia emission measurements	Reduction potential for ammonia volatilization of 68 % was measured	Reduction potential for ammonia volatilization of 71% was measured	-	Reduction potential for ammonia volatilization of 67 % was measured

Summary of field trials in Latvia

Latvia								
Year	2018							
Plant	Maize	Rye	Winter wheat + spring barley					
Slurry	Pig	Pig	Pig					
SAT type	In-field	In-field	In-field					
Used amount of sulphuric acid (l / tn slurry)	3	1,5	0,5	1,0	1,5	2,0	2,5	3,0
Slurry pH before acidification	8.1	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Slurry pH after acidification	7.5	6.4	7.6	6.5	6.4	6.3	6.2	6.0
Soil pH before field trial	6.4	6.8	6.1	not measured	6.2	not measured	not measured	6.4
Soil pH after field trial	6.4	6.8	6.1	not measured	6.3	not measured	not measured	6.4
Amount of spread slurry (m^3/ha)	30	30	30	30	30	30	30	30
Amount of S (kg/ha) to the field with untreated slurry	0	20	20	20	20	20	20	20
Amount of S (kg/ha) to the field with acidified slurry	48	27	9	17	27	35	43	60
Change in yield due to acidification	300 kg/ha better yield compared to untreated slurry (no mineral fertilizer treatment)	No difference between acidified slurry and mineral fertilizer but untreated slurry had 500 kg/ha better yield compared to them.	No change in yield	No change in yield	100 kg /ha better yield compared to untreated slurry (no mineral fertilizer treatment)	200 kg /ha better yield compared to untreated slurry (no mineral fertilizer treatment)	500 kg /ha better yield compared to untreated slurry (no mineral fertilizer treatment)	100 kg /ha better yield compared to untreated slurry (no mineral fertilizer treatment)
Results of statistical analysis of the yield	No statistical analysis done	No statistical analysis done	No statistical analysis done					
Ammonia emission measurements	Slurry acidication significantly reduced the amount of ammonia emissions	No ammonia emission measurements done	Slurry acidication significantly reduced the amount of ammonia emissions.					

Summary of field trials in Lithuania

Lithuania					
Year	2018				
Plant	Barley	Corn	Grassland	Oats	Spring wheat
Slurry	Cattle	Cattle	Pig	Pig	Cattle
SAT type	In-field	In-field	In-field	In-field	In-field
Used amount of sulphuric acid (l / tn slurry)	1,6	1,6	1,8	1,8	1,6
Slurry pH before acidification	7.57	7.57	6.83	6.83	7.57
Slurry pH after acidification	5.36	5.36	5.47	5.47	5.47
Soil pH before field trial	6.2	6.2	6	6.2	5.9
Soil pH after field trial	5.8	5.76	5.75	5.81	5.75
Amount of spread slurry (m^3/ha)	28	28	26,5	26,5	26,5
Amount of S (kg/ha) to the field with untreated slurry	3,08	3,08	4,77	4,77	3,08
Amount of S (kg/ha) to the field with acidified slurry	26,25	26,25	29,68	29,68	26,25
Change in yield due to acidification	About 500 kg/ha better yield compared to untreated slurry and about 600 kg/ha better compared to mineral fertilizer	About 2000 kg/ha better yield compared to untreated slurry but about 300 kg/ha lower yield compared to mineral fertilizer.	Almost 1300 kg better yield compared to untreated slurry and about 1000 kg/ha better than mineral fertilizer.	160 kg/ha better yield compared to untreated slurry and 40 kg/ha lower yield compared to mineral fertilizer.	About 200 kg/ha lower yield compared to both untreated slurry and mineral fertilizer
Results of statistical analysis of the yield	No statistical analysis done	No statistical analysis done	No statistical analysis done	No statistical analysis done	No statistical analysis done
Ammonia emission measurements	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done

Summary of field trials in Poland

Poland						
Year	2017				2018	
Plant	Winter barley	Spring barley	Grassland	Grassland	Grassland	Grassland
Slurry	Pig	Cattle	Cattle	Cattle	Cattle	Cattle
SAT type	In-field	In-field	In-storage	In-storage	In-storage	In-storage
Used amount of sulphuric acid (l / tn slurry)	4,5	4,8	3,5	3,5	3,5	3,5
Slurry pH before acidification	7.4	7.2	7.4	7.3	7.3	7.1
Slurry pH after acidification	5,2	5.0	5.5	5.5	5.5	5.4
Soil pH before field trial	4.9	6.5	6.4	6.5	6.5	6.3
Soil pH after field trial	5.6 (acidified slurry) and 6.6 (untreated slurry)	5.5 (acidified slurry) and 6.9 (untreated slurry	6.0	6.1	6.1	6.2
Amount of spread slurry (m^3/ha)	36	36	39 / 48 / 52	39 / 48 / 52	39 / 48 / 52	39 / 48 / 52
Amount of S (kg/ha) to the field with untreated slurry	0,5	0,5	4,2	3,0	8,2	3
Amount of S (kg/ha) to the field with acidified slurry	4,5	3,6	310	312	312	312
Change in yield due to acidification	Almost 4000 kg/ha better yield compared to untreated slurry.	About 500 kg/ha better yield compared to untreated slurry.	-	-	-	-
Results of statistical analysis of the yield	No statistical analysis done	No statistical analysis done	No statistical analysis done	No statistical analysis done	No statistical analysis done	No statistical analysis done
Ammonia emission measurements	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done

Summary of field trials in Sweden

Sweden					
Year	2016	2017	2018		
Plant	Grassland	Grassland	Grassland	Spring barley	Maize
Slurry	Cattle	Cattle	Cattle	Digestate	Cattle
SAT type	In-field	In-field	In-field	In-field	In-field
Used amount of sulphuric acid (l / tn slurry)	5	3,25	4,2	4	-
Slurry pH before acidification	7.1	7.0	7.1	8.4	-
Slurry pH after acidification	5.5	6.4	6.0	6.5	-
Soil pH before field trial	Not measured	Not measured	Not measured	5.9	-
Soil pH after field trial	Not measured	6.1	Not measured	Not measured	-
Amount of spread slurry (m^3/ha)	24	24	24	24	-
Amount of S (kg/ha) to the field with untreated slurry	10	12	12	61	-
Amount of S (kg/ha) to the field with acidified slurry	73	48	64	326	--
Change in yield due to acidification	About 400 kg/ha better yield compared to untreated slurry	350 kg lower yield compared to untreated slurry.	200 kg/ha better yield compared to untreated slurry.	120 kg better yield compared to untreated slurry.	-
Results of statistical analysis of the yield	No significant difference between untreated and acidified slurry	No significant difference between untreated and acidified slurry	No significant difference between untreated and acidified slurry	No statistical analysis done	-
Ammonia emission measurements	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done	No ammonia emission measurements done

www.balticslurry.eu

Summary of the project

Baltic Slurry Acidification is an agro-environmental project financed by Interreg Baltic Sea Region under the priority area Natural resources and specific objective Clear Waters. The aim of the project is to reduce nitrogen losses from livestock production by promoting the use of slurry acidification techniques in the Baltic Sea Region and thus to mitigate eutrophication of the Baltic Sea. Baltic Slurry Acidification project was implemented in the period March 2016 - February 2019.

Summary of the report

Acidification of slurry to reduce ammonia emissions can also improve the nitrogen availability to plants, but the benefit varies from year to year and is much dependent on the soil nutrient status and weather conditions during the growing season. The field trials showed that acidification resulted in similar or higher yields compared to untreated slurry, but the yield difference was not statistically significant. The growth of plants and the yield and quality formation was normal. Slurry acidification can be regarded as one tool for farmers to mitigate ammonia emissions when spreading conditions are unfavorable.

Contributing partners: Estonian Crop Research Institute, Association of ProAgria Centres Finland, State Agency for Agriculture, Environment and Rural Areas of the German Federal State Schlesw Germany, Latvian Rural Advisory and Training Centre, Animal Science Institute of Lithuanian University of Health Sciences, Institute of Technology and Life Sciences Poland, Agricultural Advisory Center Poland, RISE Research Institutes of Sweden, The Rural Economy and Agricultural Society Sweden