Guidelines for Land Application of Acid Whey

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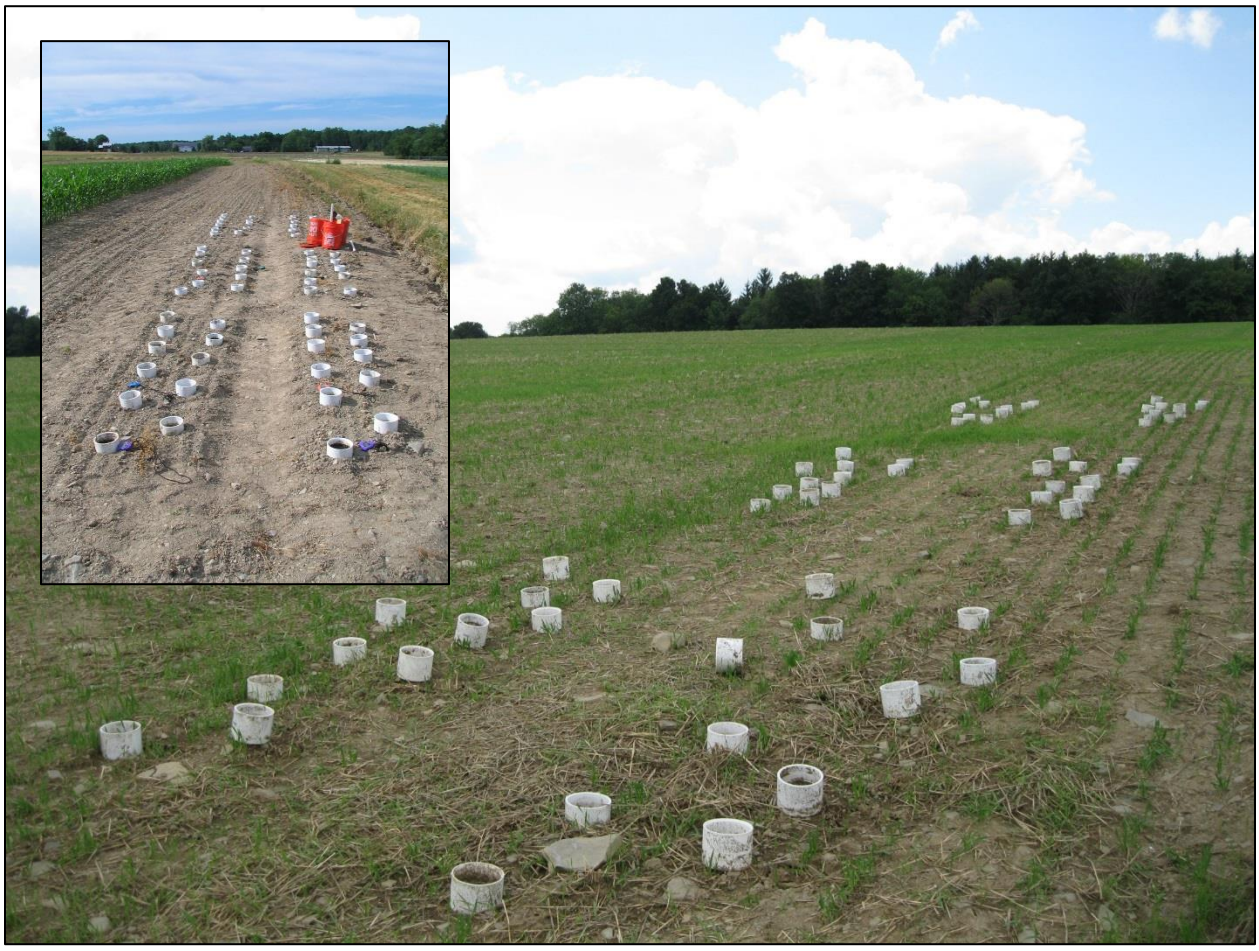
Acid whey incubation studies were conducted to determine the impact of acid whey addition on soil pH over time.

Guidelines for Land Application of Acid Whey

Executive Summary

- Acid whey, a coproduct of Greek yogurt, cottage cheese, and cream cheese manufacturing, contains nutrients that can be useful for crops.
- The term acid whey reflects the low pH of the whey, typically ranging from 3.6-4.5 with an average value of 4.1. Sweet whey, a coproduct from the production of hard cheeses, often has a pH of 5.6 or higher, by comparison.
- Land application of acid whey is governed by the New York State Department of Environmental Conservation (NYSDEC) Part 360 (http://www.dec.ny.gov/regs/2491.html) solid waste regulation unless the farm is a Concentrated Animal Feeding Operation (CAFO), in which case the Concentrated Animal Feeding Operation (CAFO) Permits govern.
- Application rate can be limited by either nitrogen or phosphorus content of whey (based on crop needs and the New York phosphorus index), chloride content, or soil characteristics and conditions that regulate infiltration rates.
- The Part 360 regulations limit annual chloride (Cl) applications to 170 lbs Cl/acre. The average Cl content of acid whey in this study was 9.3 lbs Cl/1000 gallons. The annual application limit of an acid whey source of 9.3 lbs Cl/1000 gallons is just over 18,000 gallons/acre.
- A rate of 18,000 gallon/acre also supplies approximately 130 lbs of total N, 250 lbs of P_2O_5, 300 lbs of K_2O, 180 lbs of calcium, 15 lbs of magnesium, 11 lbs of sulfur, and small amounts of boron, iron, manganese and copper.
- Land-application of acid whey first results in a rapid decrease of soil pH, quickly followed by a sharp increase to levels higher than the initial soil pH and then a gradual decline over time. This pH swing can be as large as 2 pH units, depending on rate of application, initial soil pH and soil type and may last up to 4 weeks. Because of this pH swing, acid whey can impact establishment and growth of pH sensitive crops.
- For well-buffered, high pH soil types, such as Honeoye, applications up to 18,000 gallons/acre will not impact the final soil pH. In acid soils, the pH eventually settles below the initial soil pH, increasing lime requirements for crop production over time.
- If acid whey is added to manure storage (up to a 1:1 ratio), the manure buffers the whey and the resulting mixture will have little or no effect on soil pH. When acid whey and manure are mixed, the mixture behaves like manure.
- Land application of fresh acid whey does not present an odor issue, but acid whey odor may increase significantly with time in storage and when co-stored with manure. If there are concerns about odor, incorporate or inject the acid whey or acid whey-manure mixtures.
- Infiltration of acid whey into soil is more rapid than for manure, but acid whey may still pose a runoff risk when solids content is elevated (acid whey is typically 2.5 to 6.5% solids, averaging 5.1%), and initial soil moisture content is high. Managing rates for quick infiltration and minimizing ponding time of the acid whey in the field will reduce runoff risk. Like sweet whey, acid whey needs to be tested so that nutrient levels can be used to determine application rates that meet crop needs and so that regulatory limits are not exceeded.
- Farms that are already nutrient dense (high animal density and no manure or crop export) may not be the overall best place for land application of any whey material. For those farms, import of (acid) whey may contribute to build up of soil test phosphorus beyond optimum levels.



Acid whey infiltration studies were conducted at several locations in New York.

Disclaimer

This guidance document reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

1. Introduction

Whey is a coproduct of many familiar processed milk products. In general, there are two types of whey: sweet whey and acid whey. Sweet whey is a coproduct of cheese production, and the dairy processing industry has been handling large amounts of sweet whey in the region for many decades. Acid whey is a coproduct of foods such as Greek style yogurt, cottage cheese and cream cheese. Though we have manufactured cottage cheese and cream cheese in the region for many decades as well, the sharp increase of Greek style yogurt production substantially increased the acid whey available. Greek style yogurt generates 3 parts acid whey for 1 part yogurt. While sweet whey from making cheese has a pH similar to rainwater (> 5.6), the pH of acid whey is less than 5.1 and can be less than 4.0. The whey is acidic due to the fermentation of sugar into lactic acid. While sweet whey has commercial uses in products such as nutritional supplements, products and related markets for acid whey derivatives need more development. Currently acid whey is being added to manure storage (with or without anaerobic digestion) prior to land application, spread directly on crop fields, used as a feed source, or processed through municipal wastewater treatment systems. Land application of acid whey is governed by the New York State Department of Environmental Conservation (NYSDEC) Part 360 solid waste regulations unless the farm is a Concentrated Animal Feeding Operation (CAFO), in which case the CAFO Permits govern. These regulations ensure that farms apply whey in ways that reduce the risk of impacting water resources.

The environmental risks of acid whey land application have received significant attention in the popular press. There have been whey spills into waterways resulting in fish kills. However, these have been the results of accidental discharges from processing facilities or on-farm storage. They were not the result of land application. Direct land application efforts should include plans for managing accidental spills if they occur and loading areas should be located away from streams when possible.

Like any nutrient source, land applied acid whey has the potential to run off or leach into surface and groundwater. In addition, acid whey has a high biochemical oxygen demand (Robbins and Lehrsh, 1998) meaning that it will rapidly consume oxygen as it decomposes in water. In the event of a spill, the lack of oxygen in the water (hypoxia) can lead to the death of fish and other aquatic life.

Land application of fresh acid whey does not present an odor issue (Kelling and Peterson, 1981), but odor may become an issue when acid whey is stored either alone or with manure. Potential odor concerns may be addressed by incorporating or injecting acid whey or acid whey-manure mixtures.

2. Benefits of Application

Acid whey contains nutrients beneficial to crops such as nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S). These nutrients are found in sufficient quantities and proportions to allow for the use of acid whey to either substitute or complement application of inorganic fertilizer or manure. It also contains elements such as chloride and sodium that could be detrimental to crop growth. On dairy and livestock farms, the importation of acid whey should be considered carefully to make sure the additional nutrients will meet short- and long-term goals and that the nutrients can be recycled to meet crop needs.

3. pH and Nutrient Composition

3.1 pH

The term "acid whey" reflects the low pH of the substance, which typically ranges from pH 3.5-4.5 with a mean value of 4.1 (Table 1). In contrast, sweet whey, a co-product from the production of hard cheeses, often has a pH of 5.6 or higher.

3.2 Solids and Organic Matter

Acid whey is mostly water with 2.5 to 6.5% solids, averaging 5.2% (Table 1). Solids can impact infiltration with more rapid soil infiltration when the percent solids is low. Given the same solids content, acid whey infiltrates faster than manure (see Agronomy Factsheet #96).

Table 1. Composition of acid whey from three processing facilities in New York State.

	Unit	N	Minimum	Maximum	Median	Average	Standard deviation
pH		36	3.55	4.48	4.22	4.11	0.31
Solids	%	52	2.49	6.53	5.72	5.16	1.24
Total nitrogen	lbs/1000 gallons	52	1.87	21.56	4.64	7.10	6.47
Ammonia-N	lbs/1000 gallons	52	0.00	1.34	0.00	0.23	0.42
Organic-N	lbs/1000 gallons	52	1.58	21.56	4.59	6.87	6.32
Phosphorus as P_2O_5	lbs/1000 gallons	52	10.06	16.19	14.20	14.11	1.03
Potassium as K_2O	lbs/1000 gallons	52	11.89	17.73	16.22	16.09	1.08
Calcium	lbs/1000 gallons	52	7.57	11.42	10.19	10.15	0.72
Magnesium	lbs/1000 gallons	52	0.59	0.94	0.84	0.83	0.07
Sodium	lbs/1000 gallons	52	2.61	3.68	3.26	3.28	0.21
Sulfur	lbs/1000 gallons	48	0.42	1.42	0.51	0.61	0.28
Zinc	lbs/1000 gallons	48	0.03	0.04	0.03	0.03	0.00
Chloride	lbs/1000 gallons	25	6.59	15.77	9.01	9.25	1.84

3.3 Chloride

The chloride (Cl) content of acid whey ranges from 6.6 to 15.8 lbs/1000 gallon with a mean value of 9.3 lbs/1000 gallons. New York State (NYS) law prohibits chloride application in excess of 170 lbs Cl/acre (NYS Environmental Conservation Law Part 360). Chloride applied at high rates may inhibit seed germination and a plant's ability to uptake water. At the mean value of 9.3 lbs Cl/1000 gallons, the annual maximum Cl application rate is triggered at just over 18,000 gallon/acre. The wide range in Cl in the samples analyzed (Table 1) suggests that whey sources should be tested regularly to determine the allowable rate for direct land application. The average Cl content of dairy manure tends to be lower than acid whey. As a result, when mixed with manure, the Cl content of the manure-acid whey mixture will be lower than acid whey alone.

3.4 Nitrogen

Nitrogen in the acid whey samples tested was primarily in organic-nitrogen form and varied considerably across samples with a range of 1.9 to 21.6 lbs/1000 gallons and a mean value of 7.1 lbs/1000 gallons (Table 1). At the mean N value, an application rate of 18,000 gallons/acre supplies

about 135 lbs of total N/acre. Not all this N will be plant available, but users should credit a portion of the organic N in the crop year in which the whey is applied. The availability of organic N in acid whey has not been evaluated, but using manure as an example, 35% of the organic N is typically credited for the crop year in which manure is applied. Additional research is needed to determine if N release from the organic N in whey is different from N release from manure.

3.5 Phosphorus

Acid whey supplies P, expressed here as P_2O_5 (fertilizer equivalent), with content ranging from 10.1 to 16.2 lbs/1000 gallons, averaging 14.1 lbs P_2O_5 /1000 gallons (Table 1). At this average value, an 18,000 gallons/acre application rate supplies about 250 lbs of P_2O_5. A corn silage crop will typically take up about 4 lbs of P_2O_5 per ton of silage (at 35% dry matter). Thus, a 20 tons/acre corn silage crop removes about one third of the amount of P_2O_5 supplied by an 18,000 gallons/acre acid whey application. For this reason, use of acid whey needs to be combined with monitoring of soil test P levels over time to manage P buildup and potential runoff losses.

3.6 Potassium

The potassium as K_2O content of acid whey ranged from 11.9 to 17.7 lbs/1,000 gallons with a mean value of 16.1 lbs/1000 gallons (Table 1). At the mean value, an application of 18,000 gallons/acre of acid whey will supply nearly 300 lbs/acre of K_2O. Thus, acid whey if applied at this rate will supply more than what is annually removed with harvest of crops like corn or alfalfa. It is recommended to check the K content of forages harvested from whey-amended fields and if high in K, to avoid feeding such forages to dry cows.

3.7 Calcium, Magnesium and Sulfur

The average calcium, magnesium and sulfur content for the sources tested were 10.1, 0.8 and 0.6 lbs/1000 gallons, respectively (Table 1). At the mean values, an application of 18,000 gallons/acre supplies 182 lbs of calcium, 15 lbs of magnesium and 11 lbs of sulfur.

3.8 Sodium and Micronutrients

Acid whey averaged 3.3 lbs of sodium per 1000 gallons (Table 1). The sodium content is unlikely to cause problems in New York. Acid whey also contains small amounts of boron, iron, manganese and copper.

4. Acid Whey Sampling and Testing

Samples of acid whey should be taken annually to properly credit nutrients and prevent over application. Samples taken from the delivery truck or from a recently filled tank will be most representative as settling of solids can occur during storage. Samples that cannot be analyzed immediately should be maintained at 4°C. Whey samples are usually analyzed as manure in a package that includes solids content and most of the nutrients listed above. Chloride and pH are often not included in a standard manure test package, but can be added. Soil samples should also be taken frequently to identify trends in soil nutrients and pH.

5. Impact of Soil pH

At 10,000 to 40,000 gallons/acre, rates that were tested in a laboratory study, land-application of acid whey to non-calcareous soil first resulted in a rapid decrease of soil pH, quickly followed by a sharp increase to levels higher than the initial soil pH and then a gradual decline. This swing in soil pH can be as large as 2 pH units (depending on application rate, original soil pH, soil type), and may last 1-4 weeks (Figure 2A). A pH increase was measured in the first 2-3 weeks in a calcareous soil as well (Figure 2C) but only at the highest rate (40,000 gallons/acre) was there a significant decline in pH right after application. Due to this pH swing, land application of acid whey could change soil dynamics and early plant development. Therefore, it is recommended to delay planting of pH sensitive crops for at least two weeks after whey application to eliminate salt/soil acidity effect on germination (see Agronomy Factsheet #97).

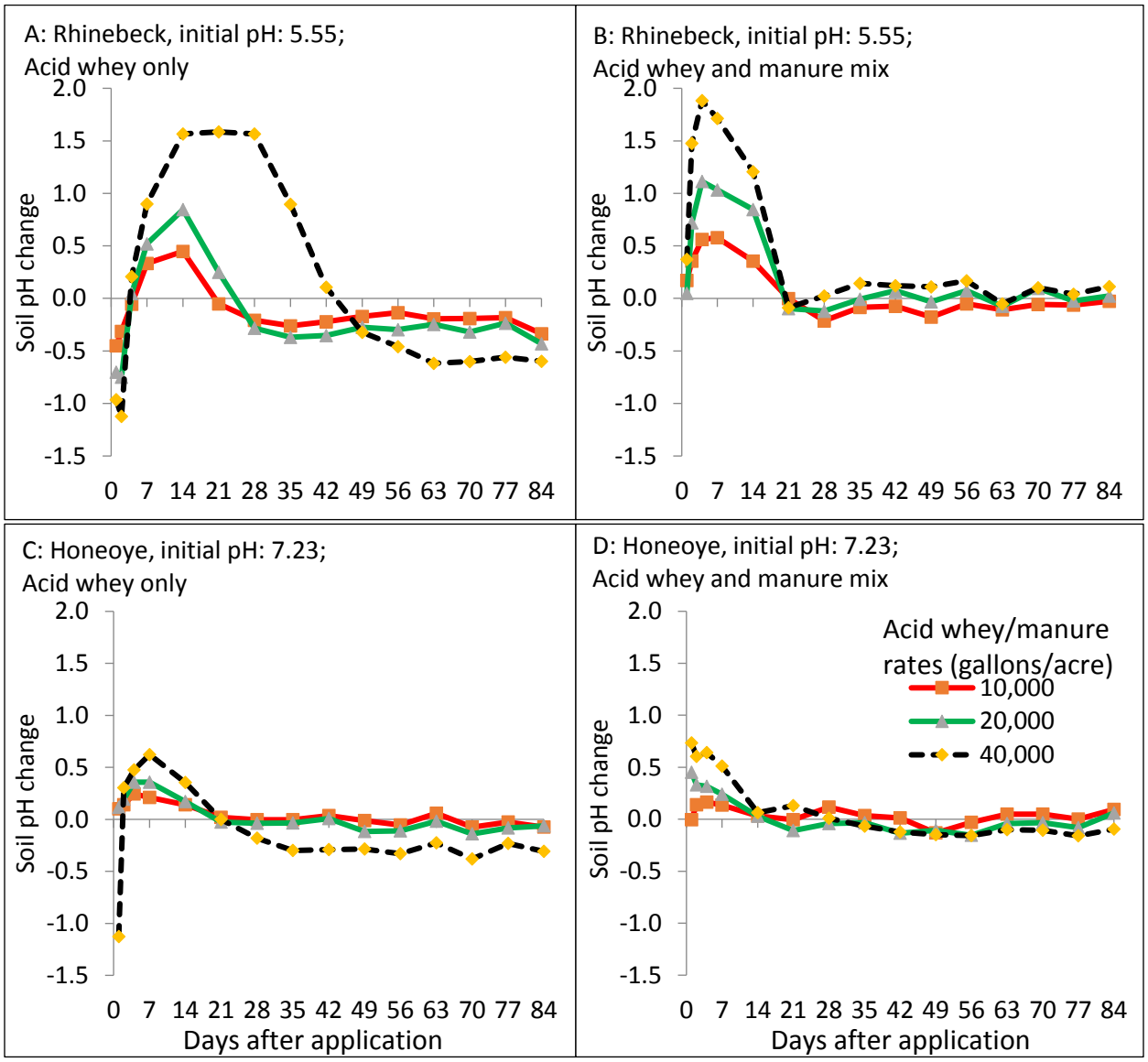


Figure 2. Soil pH change resulting from addition of acid whey alone (A and C) versus a 1:8 (volume) mixture of acid whey and manure (B and D).

In acid soils, especially soils with a pH of 5.5 or less, the pH eventually settles at a level below the starting pH before application, creating a net pH decrease (Figure 2A; Rhinebeck soil example). A net decrease in pH also occurred when 40,000 gallons/acre was applied to the calcareous soil. In the long-term, acid whey addition to already acid soils will increase lime requirements for optimal crop production. For well-buffered, high pH soils, applications at a rate of 10,000 to 20,000 gallons/acre will still cause a pH swing, but the applications will not impact the final soil pH (Figure 2C; Honeoye soil example).

When acid whey was mixed with manure, the pH of the soil increased after application (up to 2 pH units depending on the application rate and soil type; Figures 2B and 2D) and remained elevated for about 2-3 weeks but there was no net effect of soil pH beyond this initial period.

6. Potential Crop Sensitivity

Unlike manure, whey does not stick to plant leaf surfaces so smothering of plants is not expected. However, growers have reported foliar damage to plant tissue following acid whey application. We were not able to duplicate this in controlled studies. Fall applications of 10,000 and 20,000 gallons/acre of acid whey on grass did not result in tissue damage. Salt in whey is unlikely to cause problems when applied at agronomic rates. If concerned about salt sensitive crops (such as soybeans or red clover), time application at least two weeks from expected planting dates or delay planting by two weeks to allow salt to leach by rainfall (Kelling and Peterson, 1981).

7. Application Rates

Similar to the solids in manure, solids in acid whey can plug soil pores and influence infiltration rate. When acid whey and manure are mixed, the mixture behaves like manure. Field testing of infiltration rates of acid whey itself compared to liquid manure or water on four different tilled soils has shown that acid whey infiltrates slower than water but faster than manure with a comparable solids content (Figures 3 and 4).

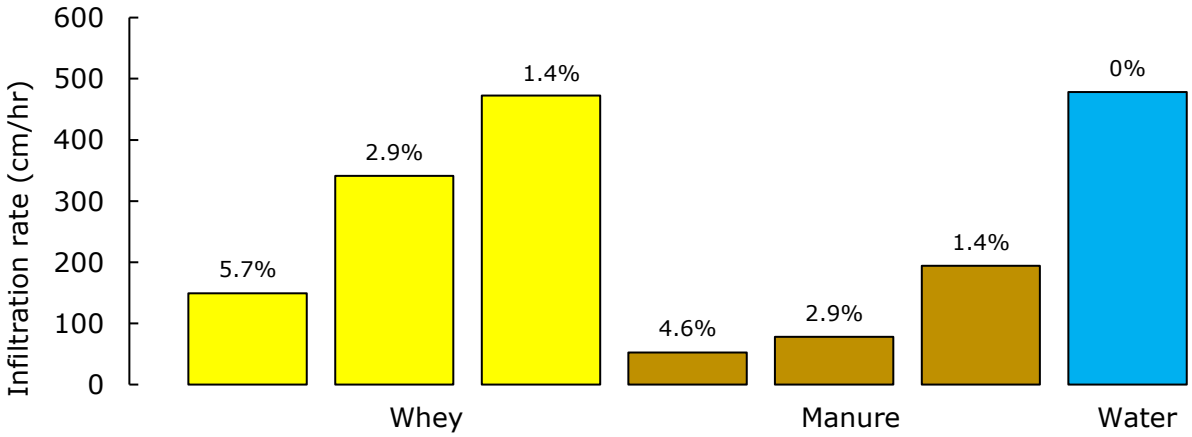


Figure 3: Infiltration rate of acid whey and manure (10,000 gallons/acre) averaged over three conventionally tilled silt loam soils as influenced by % solids in the whey and manure. Soil with excellent tilth would be expected to infiltrate more rapidly for a given solids content.

Figure 4. Comparison of the infiltration of 20,000 gallons/acre acid whey and manure. Whey (left) infiltrated completely in 10 minutes leaving a small amount of residue on the surface. Manure (right) at the same solids content (5.7%) infiltrated slower.

The solids content of acid whey impacts infiltration; the lower the solids content, the faster the infiltration rate (Figure 3). In addition, the first 10,000 gallon/acre of acid whey typically infiltrates more quickly than the second 10,000 gallons/acre application, probably reflecting differences in initial soil moisture content (Figure 5). Soil moisture impacts whey infiltration rate, with rates as much as five times faster on dry soils (Figure 6).

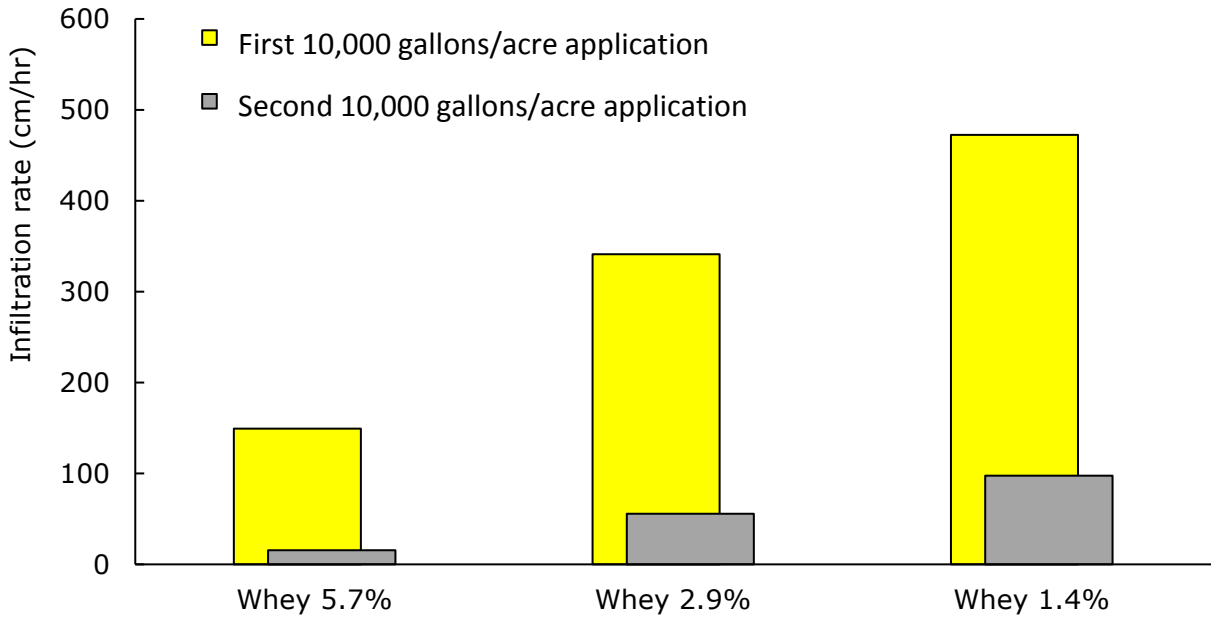


Figure 5: The 2nd 10,000 gallons/acre application of acid whey infiltrated much slower than the 1st application of 10,000 gallons/acre.

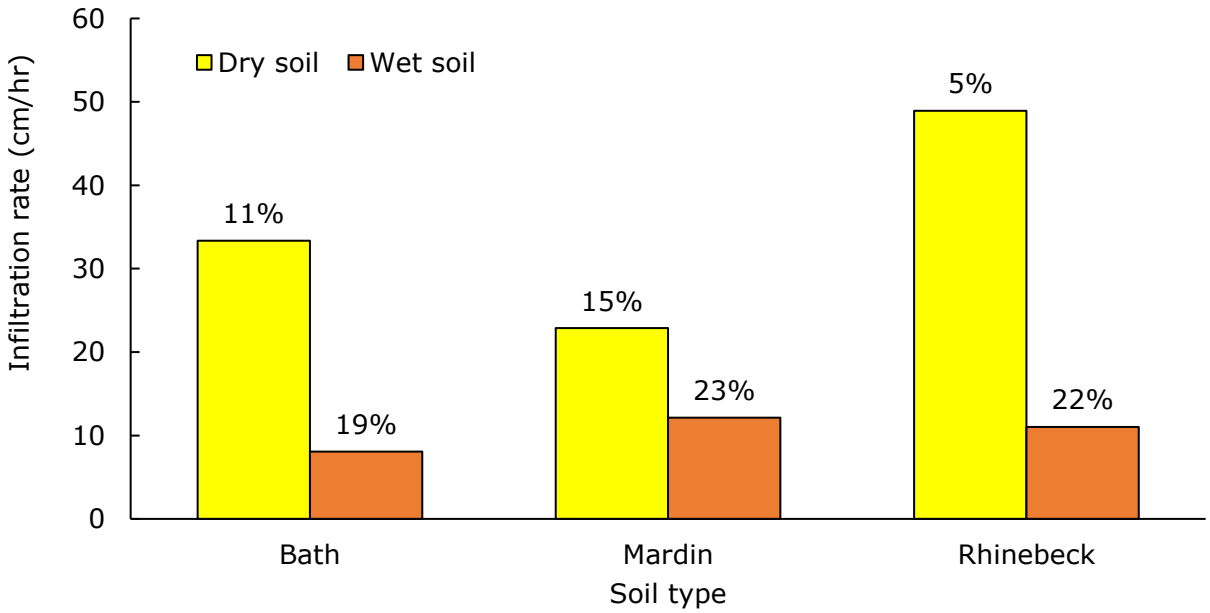


Figure 6: Infiltration rates of 20,000 gallons/acre of acid whey at 5.7% solids were significantly higher on dry soils than wet soils.

When land-applying acid whey:

- If acid whey is mixed with manure and then land-applied, treat the mixture as if it were straight manure.
- If acid whey is direct-applied to crop land:
  - Consider initial pH and the soils' ability to maintain pH in the optimal range for crop production. Additional lime will be needed to maintain soil pH over time for naturally acidic and poorly buffered soil.
  - Due to the pH swing within the first four weeks after application, avoid seeding pH sensitive crops directly after application.
  - Infiltration rates are impacted by soil type and initial moisture content; managing rates for quick infiltration and minimizing ponding time of the acid whey in the field will reduce runoff risk.
  - Application rate can be limited by either nitrogen or phosphorus content of whey (based on crop needs and the New York phosphorus index), chloride content (not to exceed the 170 lbs Cl/acre annual limit), or soil characteristics and conditions that regulate infiltration rates. Test whey and soils to set appropriate rates.

The New York State Department of Environmental Conservation Part 360 regulation (non-recognizable food processing waste; 360-4.2(b)(1); http://www.dec.ny.gov/regs/2491.html) adds restrictions to land application of acid whey as well:

- Limit rates based on chloride content (<170 lbs Cl/acre per year) and/or nutrient content.
- For land-application of acid whey, the field slope of the receiving field must be less than 8% unless whey is injected parallel to the contour.

- Ground water or bedrock must be greater than 24 inches below surface.
- Apply only to sandy loam, sandy clay loam, loam, silt loam, silt, sandy clay and clay loam.
- Apply no more than 16,000 gallons/acre in any 24 hour period.
- Maintain the following setbacks:
    - Property line: 50 feet.
    - Residence, place of business or public contact area: 500 feet.
    - Potable water well: 200 feet.
    - Surface water and State-regulated wetland: 200 feet (waste not directly injected into the soil) or 100 feet (waste directly injected).
    - Drainage swale: 25 feet.
- Land application to frozen ground is permitted if the slope of the field is less than 4% or the distance to a surface water or State-regulated wetland is at least 500 feet and berms are used.

For livestock farms operating with a CAFO Permit, the permit governs acid whey applications in a similar manner to the Part 360 regulations through application restrictions, recordkeeping requirements and integration into a farm's Comprehensive Nutrient Management Plan.

References

- Gami, S.K., Godwin, G.S., Czymmek, K.J., Ganoe, K.H., and Ketterings, Q.M. 2016. Acid whey pH and nutrient content. Cornell Agronomy Factsheet #96. Cornell University, Ithaca, NY; http://nmsp.cals.cornell.edu/publications/factsheets/factsheet96.pdf.
- Godwin, G.S., Gami, S.K. Czymmek, K.J., Ganoe, K.H., and Ketterings, Q.M. 2017. Guidelines for land application of acid whey. Cornell Agronomy Factsheet #97. Cornell University, Ithaca, NY; http://nmsp.cals.cornell.edu/publications/factsheets/factsheet97.pdf.
- Kelling, K.A, and Peterson, A.E. 1987. Using whey on agricultural land – a disposal alternative. Extension Bulletin A3098. University of Wisconsin, Madison, WI.
- New York Solid Waste Management Facilities (Part 360; NYDEC); http://www.dec.ny.gov/regs/2491.html.
- Robbins, C.W., and Lehrsh, G.A. 1998. Cheese whey as a soil conditioner. In: Handbook of soil conditioners. A. Wallace and R.E. Terry (editors). Marcel Dekker, Inc., New York, NY. pp 167-186.

Appendix A: Agronomy Factsheet 96 (Acid Whey pH and Nutrient Content)

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Agronomy Fact Sheet Series — Fact Sheet 96

Acid Whey pH and Nutrient Content

Acid whey (AW) is a co-product from the production of Greek yogurt, cottage cheese and cream cheese. In general, three of every four pounds of milk used in Greek yogurt production become acid whey. Often, acid whey is used as a feed source for cows, directly land-applied, co-digested with manure, or added to manure in storage structures on farms. Acid whey contains nitrogen (N), phosphorus (P) and potassium (K) and other nutrients that can benefit crops. On dairy and livestock farms, the importation of acid whey should be considered carefully to make sure the additional nutrients will meet short- and long-term goals and that the nutrients can be recycled to meet crop needs. In this factsheet, we present pH and nutrient composition of acid whey from a limited set of processing facilities in New York.

pH

The name acid whey reflects the low pH of the whey, typically ranging from 3.6-4.5 with an average value of 4.1 (Table 1). Sweet whey, a co-product from the production of hard cheeses, often has a pH of 5.6 or higher, by comparison. At a rate of 10,000 to 20,000 gallons/acre, land-application of acid whey first results in a rapid decrease of soil pH, quickly followed by a sharp increase to levels higher than the initial soil pH and then a gradual decline. This swing in soil pH can be as large as 2 pH units and may last for 1-4 weeks. In acid soils, the pH eventually settles at a level below the starting pH before application, creating a net pH decrease. In the long-term acid whey addition to already acid soils will increase lime requirements for optimal crop production. For well-buffered, high pH soils, applications at a rate of 10,000 to 20,000 gallons/acre will still cause a pH swing but the applications will not impact the final soil pH.

Solids and organic matter

Acid whey is mostly water with 2.5 to 6.5% solids, averaging 5.2% (Table 1). Solids can impact infiltration with more rapid soil infiltration when the percent solids is low. Given the same solids content, acid whey infiltrates faster than manure (see Factsheet #97).

Chloride

The chloride (Cl) content of AW ranges from 6.6 to 15.8 lbs/1000 gallon with an average value of 9.3 lbs/1000 gallons. New York State (NYS) law prohibits chloride application in excess of 170 lbs Cl/acre per year (NYS Department of Environmental Conservation Part 360). Chloride applied at high rates may inhibit seed germination and a plant's ability to uptake water. At the average value of 9.3 lbs Cl/1000 gallons, the annual maximum Cl application rate is triggered at just over 18,000 gallon/acre. This example upper limit rate will be used to illustrate application rates of other nutrients throughout this fact sheet. The wide range in Cl in the samples analyzed (Table 1) suggests that whey sources should be tested regularly to determine the allowable rate for direct land application. When mixed with manure, the Cl content of the manure-acid whey mixture will be lower.

Nitrogen

Nitrogen in the acid whey samples tested was primarily in organic-nitrogen form and varied considerably across samples with a range of 1.9 to 21.6 lbs/1000 gallons and an average of 7.1 lbs/1000 gallons (Table 1). At the average N value, an application rate of 18,000 gallons/acre supplies about 130 lbs of total N/acre. Not all this N will be plant available, but users should credit a portion of the organic N in the crop year in which the whey is applied. The availability of organic N in acid whey has not been evaluated, but using manure as an example, 35% of the organic N is typically credited for the crop year in which manure is applied. Additional research is needed to determine if N release from the organic N in whey is different from N release from manure.

Phosphorus

Acid whey supplies P, expressed as P_2O_5 (fertilizer equivalent), with content ranging from 10.1 to 16.2 lbs/1000 gallons, averaging 14.1 lbs P_2O_5 /1000 gallons (Table 1). At this average value, an 18,000 gallons/acre application rate supplies about 250 lbs of P_2O_5.

Table 1. Composition of acid whey from three processing facilities in New York State.

	Unit	N	Minimum	Maximum	Median	Average	Standard deviation
pH		36	3.55	4.48	4.22	4.11	0.31
Solids	%	52	2.49	6.53	5.72	5.16	1.24
Total nitrogen	lbs/1000 gallons	52	1.87	21.56	4.64	7.10	6.47
Ammonia-N	lbs/1000 gallons	52	0.00	1.34	0.00	0.23	0.42
Organic-N	lbs/1000 gallons	52	1.58	21.56	4.59	6.87	6.32
Phosphorus as P_2O_5	lbs/1000 gallons	52	10.06	16.19	14.20	14.11	1.03
Potassium as K_2O	lbs/1000 gallons	52	11.89	17.73	16.22	16.09	1.08
Calcium	lbs/1000 gallons	52	7.57	11.42	10.19	10.15	0.72
Magnesium	lbs/1000 gallons	52	0.59	0.94	0.84	0.83	0.07
Sodium	lbs/1000 gallons	52	2.61	3.68	3.26	3.28	0.21
Sulfur	lbs/1000 gallons	48	0.42	1.42	0.51	0.61	0.28
Zinc	lbs/1000 gallons	48	0.03	0.04	0.03	0.03	0.00
Chloride	lbs/1000 gallons	25	6.59	15.77	9.01	9.25	1.84

A corn silage crop will typically take up about 4 lbs of P_2O_5 per ton of silage (at 35% dry matter). Thus, a 30 tons/acre corn silage crop removes about half of the amount of P_2O_5 supplied by an 18,000 gallons/acre acid whey application. For this reason, use of acid whey needs to be combined with monitoring of soil test P levels over time to manage P buildup and potential runoff losses.

Potassium

The potassium as K_2O content of acid whey ranged from 11.9 to 17.7 lbs/1,000 gallons with an average value of 16.1 lbs/1000 gallons (Table 1). At the average value, an application of 18,000 gallons/acre will supply nearly 300 lbs/acre of K_2O. Thus, if acid whey is applied at this maximum rate, it will supply more than what is annually removed with harvest of crops like corn or alfalfa. It is recommended to check if forages harvested from whey-amended fields are high in K, to avoid feeding such forages to dry cows.

Calcium, Magnesium and Sulfur

The average calcium, magnesium and sulfur content for the sources tested were 10.2, 0.8 and 0.6 lbs/1000 gallons, respectively (Table 1). At the average values, an application of 18,000 gallons/acre supplies 182 lbs of calcium, 15 lbs of magnesium, and 11 lbs of sulfur.

Sodium and Micronutrients

Acid whey averaged 3.3 lbs of sodium per 1000 gallons (Table 1). The sodium content is unlikely to cause problems given rainfall patterns in New York. Acid whey also contains small amounts of boron, iron, manganese and copper, which can benefit crops.

Summary

Acid whey contains a significant quantity of several important elements and can be used as a source of plant nutrients. Nitrogen and chloride content are most variable but content of other nutrients can vary as well. Acid whey needs to be tested to determine application rates to match crop needs and so that regulatory limits are not exceeded. Farms that are already nutrient dense (high animal density and no manure or crop export) may not be the best place for acid whey. For those farms, import of acid whey may contribute to unnecessary nutrient loss when crops are not able to satisfactorily recycle the extra nutrients.

Additional Resource

- New York Solid Waste Management Part 360: www.dec.ny.gov/regulations/81768.html)

Disclaimer

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

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2016

Appendix B: Agronomy Factsheet 97 (Guidelines for Land Application of Acid Whey)

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Agronomy Fact Sheet Series **Fact Sheet 97**

Guidelines for Land-application of Acid Whey

Acid whey, a co-product of Greek yogurt, cottage cheese, and cream cheese manufacturing, contains nutrients that can be useful for crops (Factsheet #96). Like any material containing nutrients, land application can result in losses to the environment. Additionally, the low pH of acid whey can impact soil pH. In this factsheet, guidance is given for land application of acid whey.

Chloride limit and nutrient addition

New York State law limits annual chloride (Cl) applications to no more than 170 lbs/acre of Cl. Based on a limited set of samples (Factsheet #96), the average Cl content of 9.3 lbs Cl/1000 gallons triggers the annual limit at just over 18,000 gallons/acre. This rate also supplies approximately 130 lbs of total N, 250 lbs of P_2O_5, 300 lbs of K_2O, 180 lbs of calcium, 15 lbs of magnesium, 11 lbs of sulfur, and small amounts of boron, iron, manganese and copper. Thus, acid whey contains significant quantities of important nutrients. Whey sources should be tested to determine nutrient content to match applications with crop needs (Factsheet #33).

Impact on soil pH

Given the acidity, various rates of acid whey were applied to soil to test the impact on soil pH. At a rate of 10,000 or more gallons/acre, land-application of acid whey first results in a rapid decrease of soil pH, quickly followed by a sharp increase to levels higher than the initial soil pH and then a gradual decline over time. This pH swing, which can be as large as 2 pH units, may last up to 4 weeks and can impact establishment and growth of pH sensitive crops. For well-buffered, high pH soil types such as Honeoye, applications up to 18,000 gallons/acre will not impact the final soil pH. In acid soils, the pH eventually settles below the initial soil pH, increasing lime requirements for crop production over time. If acid whey is added to manure storage (up to a 1:1 ratio), the manure buffers the whey and the resulting mixture will have little or no effect on soil pH.

Odor

Land application of fresh acid whey does not present an odor issue, but acid whey odor may increase significantly with time in storage and when co-stored with manure. If there are concerns about odor, incorporate or inject the acid whey or acid whey-manure mixtures.

Infiltration rates

Similar to the solids in manure, solids in acid whey can plug soil pores and influence infiltration rate. When acid whey and manure are mixed, the mixture behaves like manure. Field testing of infiltration rates of acid whey itself compared to liquid manure or water to the surface of four different tilled soils has shown:

- Whey infiltrates slower than water but faster than manure with a comparable solids content (Figures 1 and 2).
- Solid content of the whey impacts infiltration; the lower the solids content, the faster the infiltration rate.
- The first 10,000 gallon/acre acid whey application infiltrates more quickly than the second 10,000 gallons/acre application, reflecting differences in initial soil moisture content (Figure 3).

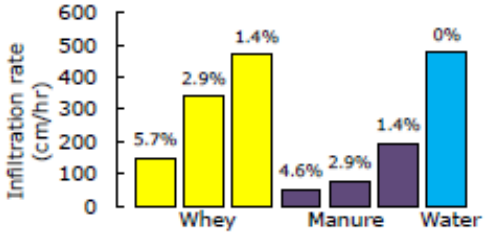

Figure 1: Infiltration rate of acid whey and manure (10,000 gallons/acre) on silt loam soils as influenced by % solids. Soil with excellent tilth would be expected to infiltrate more rapidly for a given solids content.

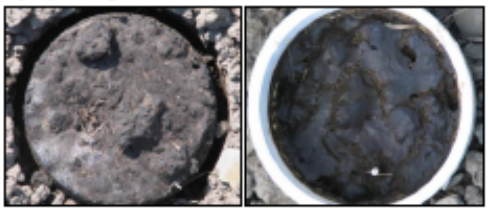

Figure 2: Comparison of the infiltration of 20,000 gallons/acre acid whey and manure. Whey (left) infiltrated completely in 10 minutes leaving a small amount of residue on the surface. Manure (right) at the same solids content (5.7%) infiltrated slower.

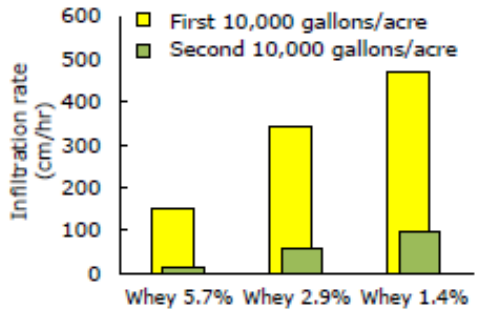

Figure 3: The 2nd 10,000 gallons/acre application infiltrated much slower than the 1st application of 10,000 gallons/acre.

Guidelines for Land Application

- If acid whey is mixed with manure and then land-applied, treat the mixture like straight manure.
- If acid whey is direct-applied to crop land:
  - Consider initial pH and the soils' ability to maintain pH in the optimal range for crop production. Additional lime will be needed to maintain soil pH over time for naturally acidic and poorly buffered soil.
  - Due to the pH swing within the first four weeks after application, avoid seeding pH sensitive crops directly after application.
  - Infiltration rates are impacted by soil type and initial moisture content; managing rates for quick infiltration and prevention of ponding of the acid whey in the field will reduce runoff risk.
- The Environmental Conservation Law of the State of New York (ECL) 360 regulation (non-recognizable food processing waste; 360 CRR-NY 360-4.2(b) and 4.6 (b)) states:
  - Limit rates based on chloride content and/or nutrient content.
  - For land-application of acid whey, the field slope of the receiving field must be less than 8% unless whey is injected parallel to the contour.
  - Ground water or bedrock must be greater than 24 inches below surface.
  - Apply only to sandy loam, sandy clay loam, loam, silt loam, silt, sandy clay and clay loam.
  - Apply no more than 16,000 gallons/acre in any 24 hour period.
  - Maintain the following setbacks:
    - Property line: 50 feet.
    - Residence, place of business or public contact area: 500 feet.
    - Potable water well: 200 feet.
    - Surface water and State-regulated wetland: 200 feet (waste not directly injected into the soil) or 100 feet (waste directly injected).
    - Drainage swale: 25 feet.
  - Land application to frozen ground is permitted if the slope of the field is less than 4% or the distance to a surface water or State-regulated wetland is at least 500 feet and berms are used.

Summary

Acid whey is a good source of nutrients for crops. Infiltration is more rapid than for manure, but acid whey may still pose a runoff risk when solids content is elevated and soil moisture content is high. Avoid seeding pH sensitive crops directly after application. Additional lime will be needed to maintain pH when acid whey is applied to naturally acidic and poorly buffered soils. Application rate can be limited by either nitrogen or phosphorus content of whey (based on crop needs and the New York phosphorus index), chloride content (not to exceed the 170 lbs chloride/acre annual limit set by ECL), or soil characteristics and conditions that regulate acid whey infiltration rates. Test whey and soils to set appropriate rates.

Additional Resources

- New York Solid Waste Management Facilities (Part 360; NYDEC); http://www.dec.ny.gov/regs/2491.html.
- Factsheet #33: Nutrient Management Planning; Factsheet #96: Acid Whey pH and Nutrient Content; http://nmsp.cals.cornell.edu/guidelines/factsheets.html.

Disclaimer

This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

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