In 2003, UW—Discovery Farms initiated a study to investigate the potential for contaminants to move from headland stacks of poultry manure into waters of the state. The UW—Discovery Farms Program worked with the poultry industry and the Department of Natural Resources (WI-DNR) on a research design which would provide answers to the questions of environmental risks. To implement the study, UW—Discovery Farms worked closely with staff from the Nutrient and Pest Management Program (NPM) to conduct three separate trials which provided information on the:

➢ Characterization of Poultry Manure;
➢ Potential Runoff of Stacked Poultry Manure;
➢ Stockpiling Manure and Soluble Salts: Site Remediation for Crop Production;
➢ Effect of Headland Stacking of Poultry Manure on Groundwater.

During Phase Two of this study, many livestock producers that have stacked manure in the field asked the same question; “when a pile of manure has been in place for a period of time, why is it difficult to establish crops on the stacking site?” The observed inhibition of plant growth is of concern to producers and to the regulatory community. Because of this interest, Phase 2 of the study was modified to evaluate this question.
A study site was selected that had characteristics and soils meeting WI-DNR permit criteria. A “typical” headland stack of poultry litter consisting of manure and bedding (6 feet high by 12 feet wide by 100 feet long) was placed on the site; that stack remained in place for one year, which is the longest period of time a stack is allowed to stay in place under the conditions of most CAFO permits. The soil on the site was a Jewett silt loam; this soil has a high water holding capacity and moderate permeability. Tests on soil samples taken at the site prior to stacking indicated a pH of 7.4, 3.3 percent organic matter, 30 ppm phosphorus, and 114 ppm potassium. The WI-DNR verified the site as a suitable location for headland stacking. The previous crop in the field was soybeans. Figure 1 shows the construction of the poultry manure stack.

The soil at the site was sampled before the stack was established and after the manure was removed. Soil samples were taken in the center of the stacking site where the depth of the pile was the greatest and at the edge of the stack around the entire perimeter. Soil samples were analyzed for a range of constituents including total nitrogen, nitrate, ammonium, phosphorus, potassium, manganese, and other soluble salts. Though somewhat peripheral to the main objectives of the study, these data were collected to address grower concern about the difficulties they often encounter in their efforts to establish crops on stacking sites after the manure is removed. After one year the manure stack was deconstructed and the manure was applied to the surrounding cropland.

Figure 1. Piling Poultry Manure
Post stacking soil analysis results revealed high levels of soluble salts, primarily ammonium, potassium, and manganese, in the upper soil profile (Figures 2-5). The presence of these salts at their elevated levels can lead to toxic conditions for germinating seeds and would largely account for the lack of plant growth on previous manure stacking sites. Because of the solubility of these accumulated salts, over a period of time (and a number of precipitation events), they are flushed from the soil and productivity returns. The high level of ammonium in the center of the stack in the upper 12 inches of the soil profile probably occurs because of the lack of oxygen and the interaction between the soil and manure as moisture moves between the stack and the soil. There are concerns that this ammonium could present a potential groundwater threat if it converts to nitrate and moves through the soil. The potential effects on groundwater are the subject of the third phase of this study and will be reported on in a separate factsheet.

While manure stack sites have not been extensively researched, plant growth inhibition associated with heavy/repeated manure applications has been well documented and are not necessarily linked to animal species.

Adriano et al.\(^1\) described lower germination and plant growth after exposure to dairy manure and concluded that high salt levels and ammonium toxicity were the cause. Murphy et al.\(^3\) found large increases in soil sodium and potassium following high applications of beef manure which resulted in yield reductions in corn silage that were attributed to high salt levels and ammonium toxicity. Mathers and Stewart\(^2\) and Reddell et al.\(^4\) also found reduced yields associated with heavy beef manure application.

Though salt build up and ammonium toxicity are the commonly cited reasons for reduced plant growth, other factors may play a role. Schuman and McCalla\(^5\) found that certain organic acids present in fresh beef manure could also reduce seed germination and seedling growth. Shortall and Liebhardt\(^6\) reported that heavy applications of poultry litter produced salinity levels in the soil that reduced crop yields.

The pH of the soil was also tested during this study (Figure 6). Surprisingly, there was little variation in pH levels before the headland stack was established and after it was removed. The consistency of the results suggests that changes in soil pH are not a factor in the lack of plant growth after a manure stack has been removed.
Remediation Recommendations

The passage of time is the ultimate solution to returning soil productivity once a stack is removed, but other techniques could be utilized. Working the soil with aggressive tillage to mix the soil and release some of the nitrogen may speed the process. Another suggestion would be to pack lime screenings or papermill sludge on the site prior to making the stack, establishing a break between the manure and soil surface. This barrier can minimize the movement of soil moisture into and out of the bottom layer of stacked manure. Minimizing the moisture cycle at the manure/soil interface can reduce extreme accumulations of ammonium and soluble salts in the soil. A lime stacking pad also provides a traction surface and minimized wheel rutting during manure clean up.

The goal should be to establish a crop on a site where manure has been stacked as quickly as possible in order to utilize the existing nutrients and to remove mobile nutrients from the soil profile. Table 1 contains a listing of agronomic plants and their relative tolerance to salts.

When establishing a crop on a stacking site, producers are encouraged to plant crops that are either tolerant or moderately tolerant to salt. One possible approach may be to remove the stack in late summer or early fall and establish a salt tolerant wheat or rye crop on the site (Table 1).

<table>
<thead>
<tr>
<th>Tolerant</th>
<th>Moderately Tolerant</th>
<th>Sensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>Sweet Clover</td>
<td>Alsike Clover</td>
</tr>
<tr>
<td>Beardless Wild Rye</td>
<td>Perennial Ryegrass</td>
<td>Red Clover</td>
</tr>
<tr>
<td>Russian Wild Rye</td>
<td>Alfalfa</td>
<td>Potatoes</td>
</tr>
<tr>
<td>Altai Wild Rye</td>
<td>Wheat</td>
<td>Corn</td>
</tr>
<tr>
<td>Fall Fescue</td>
<td>Sugar Beets</td>
<td>Orchard Grass</td>
</tr>
<tr>
<td>Kochia</td>
<td>Oats</td>
<td>Timothy</td>
</tr>
<tr>
<td>Sunflower</td>
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<td>Peas</td>
</tr>
<tr>
<td>Winter Wheat</td>
<td>Bromegrass</td>
<td>Field Beans</td>
</tr>
<tr>
<td>Spring Wheat</td>
<td>Canola</td>
<td></td>
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</tbody>
</table>

Table 1: Salt Tolerance of Various Types of Plants

Conclusions

Stockpiling can be a useful method to store manure for short to moderate periods of time. The recommendations listed above may be useful in the remediation of past manure stacking sites. However, the disadvantage is that salt tolerant plants may likely not be a desirable crop for the whole field. In Phase Three of this project we evaluated the potential of headland stacks to negatively impact groundwater quality.

References

This fact sheet is the third in a four part series that provides the information collected over a five year period on the potential environmental risks associated with headland stacking of poultry manure.

The first fact sheet provides data and information on the nutrient concentrations, percent dry matter, water holding capacity and water infiltration rates of poultry manure.

The second fact sheet provides data and information on the potential for nutrients to run off from headland stacked poultry manure into surface water.

This third fact sheet provides data and information associated with soluble salt accumulation in the soil and re-vegetation challenges after poultry manure has been headland stacked. To conduct this piece of the study, manure was stacked in a pile similar to those used by the industry. A berm was placed around the pile to channel runoff water through a flume for measuring and sampling. Soil and manure sampling were conducted before the pile was placed and after it was removed.

The final phase of this study evaluates the potential for nutrients to leach into groundwater from headland stacked manure. This piece of the study was conducted over a period of three years and evaluated well water quality before the pile was placed, during its placement, and for a period of two years after the pile was removed. A final fact sheet describing phase three of this project will be available in the spring of 2009.

Additional Information

UW-Discovery Farms  www.uwdiscoveryfarms.org

Alabama Cooperative Extension – The Value and Use of Poultry Manures as Fertilizer
www.aces.edu/pubs/docs/A/ANR-0244/ANR-0244.pdf?PHPSESSID=01ceb7217b2229ee2ee6ae2bcfc86ecb

University of Georgia Cooperative Extension – Poultry Litter Application on Pastures and Hayfields
http://pubs.caes.uga.edu/caespubs/pubcd/B1330/B1330.htm

This publication is available from the UW-Discovery Farms Office. Copies may also be printed from the website.

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Understanding Headland Stacked Poultry Manure - 3
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