# Crop/Nutrient Considerations for Biosolids

Applying biosolids to land benefits the land and provides an environmentally safe way to recycle waste. However, the benefits will be gained only by applying quantities of biosolids to supply nutrients, according to the plant needs.

## What are biosolids?

Biosolids consist primarily of a suspension of microbes and other organic materials resulting from domestic wastewater treatment processes. Each treatment plant produces biosolids having unique properties. Chemical analyses of the biosolids are needed as a basis for calculating land application rates.

## What are the regulation guidelines?

Wastewater must have certain properties to qualify as biosolids. These properties minimize risks associated with heavy metals and pathogens.

The guides for applying the waste to land are the nitrogen (N) content in the biosolids and the annual N requirement of the crop.

The regulations for land application of biosolids relate to categories of biosolids management. If the biosolids contain less than 50,000 milligrams per kilogram (5 percent) of N (dry basis) and if 2 dry tons or less are applied per acre per year, there are reduced requirements for nitrogen monitoring.

In all other cases, calculate the quantity of biosolids applied in a calendar year based upon the crop needs. The crop yield goal used for such a calculation must be appropriate for the location, average weather conditions and fresh water irrigation if used.

## Crop requirements

The plant nutrients in biosolids are mostly organic. In order for these nutrients to be available to the plant, they must be mineralized.

Calculate the total plant available nitrogen (PAN) based upon analytical results.

The crop need for N depends upon the use of the plant material, the plant species and dry matter yield potential.

***Table 1. Estimated nutrient removals by row and/or grain crops in product removed from fields for sale or feeding.***

| | | Removal | | |
|---|---|---|---|---|
| Crop | Yield unit | N | P | K |
| | | (pounds per yield unit) | | |
| Barley | bushel | 0.96 | 0.016 | 0.19 |
| Buckwheat | pound | 0.02 | 0.003 | 0.002 |
| Corn, grain | bushel | 0.90 | 0.20 | 0.24 |
| Oat | bushel | 0.64 | 0.11 | 0.15 |
| Popcorn | pound | 0.016 | 0.003 | 0.004 |
| Rye | bushel | 1.18 | 0.15 | 0.27 |
| Grain sorghum | pound | 0.014 | 0.004 | 0.004 |
| Soybeans[a] | bushel | | 0.37 | 1.20 |
| Sunflower | pound | 0.026 | 0.004 | 0.006 |
| Wheat | bushel | 1.26 | 0.26 | 0.24 |

*Source: Buchholz, D.D., 1983. Soil Test Interpretations and Recommendations Handbook, MU Department of Agronomy.*

*[a]Nitrogen (N) is fixed by bacteria in soybean nodules. When N is available in the soil, the soybean plant will use the soil N.*

Tables 1 and 2 list many crops that may be grown in Missouri. The data are expressed in pounds per yield unit.

Forages, including hay and silage, are harvested as whole plants. Grains result in removal of only a portion of the plant. Rates of biosolids for pasture are based upon the necessary N to maintain the pasture, assuming manure is returned to the grazed field by the animals.

Plants may accumulate N and potassium (K) in amounts greater than needed for the yield goal. This excess is called "luxury consumption" and is not figured into the average composition values. Future research and experience with biosolids may provide some means of incorporating luxury consumption into the calculations. The main reason it is not included is it depends on timing the biosolids application with the period of maximum growth rate of the plants.

If you regularly use biosolids on your land, analyze the produce to determine actual removals from the site. These analyses are particularly useful with hay and silage because the vegetation of the plants are more variable in composition than grain.

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*Table 2. Estimated nutrient removals by hay and silage.*

| Use | Forage | Nutrient N (Pounds per ton) | P | K |
|---|---|---|---|---|
| **Hay** | Alfalfa | | 4.3 | 48 |
| | Clover, clovergrass | | 6.4 | 48 |
| | Bermudagrass | 50 | 6.0 | 34 |
| | Cool-season grass (tall fescue, orchardgrass, bromegrass) | 45 | 7.0 | 45 |
| | Sorghum-Sudan grass | 40 | 6.6 | 47 |
| | Warm-season grass (big bluestem, indian-grass, switchgrass) | 32[a] | 4.0[c] | 34[a] |
| | Eastern gamagrass | 40[d] | 4.0[d] | 40[d] |
| **Silage** | Corn silage | 9[b] | 1.6[b] | 7.5[b] |
| | Sorghum silage | 13[b] | 2.0[b] | 8.3[b] |

*Sources: Phosphate Potash Institute, 1989. Wall chart, revised.*

*[a]Boggeman, D.L., 1987. M.S. Thesis, MU.*
*[b]Buchholz, D.D., 1983. Soil Test Interpretation and Recommendations Handbook, MU Department of Agronomy.*
*[c]Kroth, E.M. and R. Mattas. 1982. Missouri Agricultural Experiment Station Results Bulletin 1046.*
*[d]Estimates from MU field research.*

## Calculation of needs

Calculate needs, based on results from a current soil test. This sets the baseline for the soil, as well as application amounts of N, K and phosphorus (P).

Send the soil samples to the MU Soil and Plant Testing Laboratory through your local MU Extension office or to a private soil testing lab. Each soil sample needs an information sheet to help lab personnel make fertility recommendations based upon the soil test results. The information includes the following:

- Crop to be grown
- Expected yield level
- Past management details
- Site details, such as topographic location, etc.

Use reasonable yield goals, especially with N recommendations. Table 3 provides information on ceiling yields. If you have yield experience with a crop on this site, use that information. Missouri soils and weather conditions are variable, making local yield estimates more specific than a statewide figure.

Always keep in mind that unless irrigation is available, yields will be limited by available moisture in the growing season.

If you select excessively high yield goals as a basis for biosolids application, the crop will not use the excess nutrients. Surface water and groundwater become at risk from contamination, due to the unused nutrients.

Assume you tested a soil sample and the recommendation for grain corn suggests 120 pounds N, 60 pounds $P_2O_5$ and 40 pounds $K_2O$ per acre. The biosolids available have a PAN content of 6,000 milligrams per kilogram (parts per million) dry basis.

Converting the 6,000 milligrams of PAN per kilogram dry solids to pounds per dry ton (2,000 pounds) involves multiplying by 0.002:

0.002 x 6,000 milligrams per kilogram = 12 pounds PAN per dry ton

If our recommendation of 120 pounds N per acre for the corn crop is the goal, you must apply 10 dry tons of biosolids to meet the N need:

120 pounds N per acre ÷ 12 pounds PAN per ton = 10 dry tons per acre

The biosolids hauler may wish to apply less than the prescribed amount because of low biosolids content or lack of sufficient quantity. The grower also may wish to supplement the biosolids with fertilizer N.

For example, the biosolids hauler applies only 4 dry tons of biosolids of the PAN analysis. (12 pounds PAN per ton):

4 dry tons x 12 pounds PAN per ton = 48 pounds PAN applied per acre

Thus, you supplement the biosolids with 72 pounds N per acre as fertilizer N:

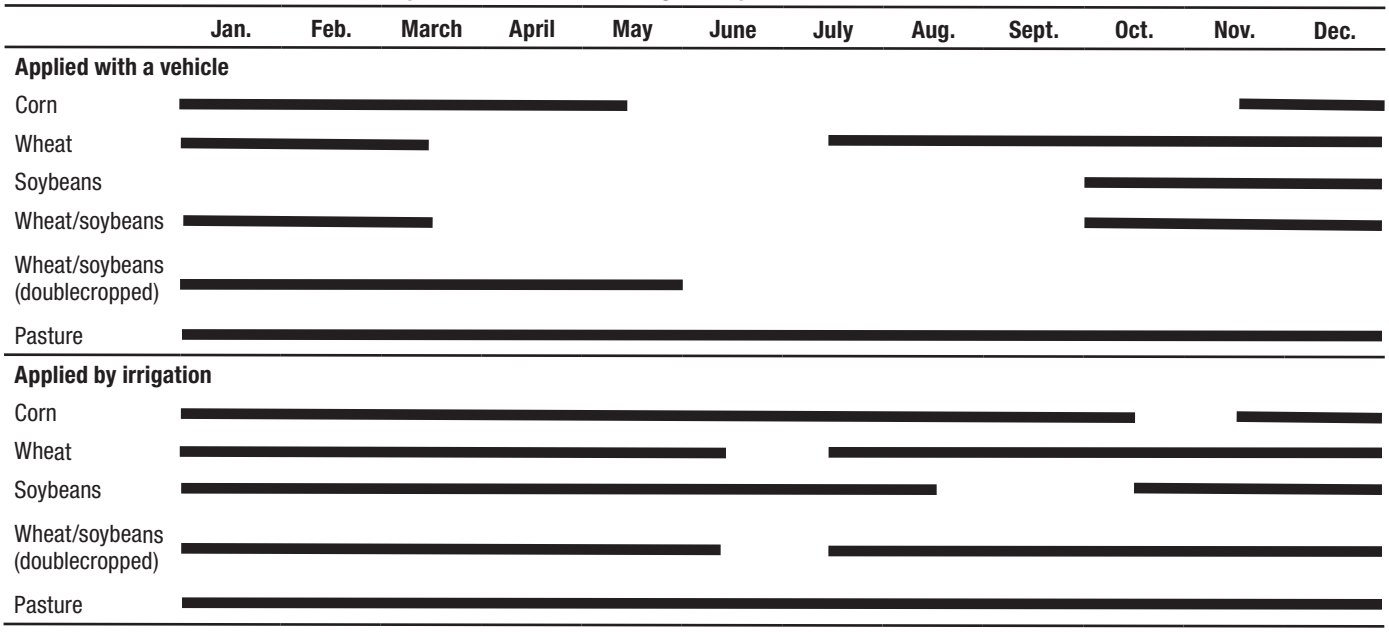
120 pounds N per acre recommended – 48 pounds PAN per acre
= 72 pounds N per acre

*Table 3. Reasonable yield limits for calculating biosolids application to land.*

| Crop | Common[a] yield goals | Irrigated Upper limits[b] |
|---|---|---|
| Corn (bushels per acre) | 80 to 250 | 220 |
| Oats (bushels per acre) | 50 to 100 | 100 |
| Grain sorghum (bushels per acre) | 4,000 to 10,000 | 10,000 |
| Soybeans (bushels per acre) | 30 to 70 | 90 |
| Sunflower (pounds per acre) | 1,200 to 2,500 | 4,000 |
| Wheat (bushels per acre) | 30 to 80 | 100 |
| Alfalfa hay (tons per acre) | 3 to 7 | 14 |
| Clover, clover green hay (tons per acre) | 2 to 5 | 8 |
| Bermudagrass hay (tons per acre) | 2 to 6 | 14 |
| Cool-season grass hay (tons per acre) | 2 to 8 | 10 |
| Sorghum-Sudan grass hay (tons per acre) | N/A | 12 |
| Warm-season grass hay (tons per acre) | 2 to 5 | 8 |
| Eastern gamagrass (tons per acre) | N/A | 10 |
| Corn silage (tons per acre) | 10 to 25 | 40 |
| Sorghum silage (tons per acre) | 12 to 30 | 40 |

*[a]Guidelines for crops, codes and common yield goals from MU publication MP0188, Soil Sample Information.*
*[b]Upper limits are based on long term averages under good management and optimum soil conditions.*

*Table 4. Land availability for biosolids application under best management practices.*




*Source: Agricultural Use of Municipal Wastewater Sludge, Missouri Department of Natural Resources, 1985.*

## Time of application

Biosolids as applied to land usually contain more than 90 percent water. Therefore, a large quantity of water must be applied to the land to achieve the desired application rate of solids. The weight resulting from the water restricts the time of field-spreading to periods when the soil is relatively dry to prevent excessive compaction. Soil compaction should be avoided because compaction restricts plant root growth, which in turn limits plant top growth.

Application time is limited when the crop is growing or at harvest, also. Table 4 provides some guidelines for application, based upon crop growth.

## Other limitations

To address other site limitations, follow Best Management Practices. Some examples are, field slopes, grassed buffer strips, soil depth, distance to steams and soil conservation practices. Biosolids may not be applied to frozen, snow-covered or saturated soil, except under certain conditions.

## Summary

Take these steps to apply biosolids:

- Take a soil test.
- Calculate crop needs from the soil test results and your crop yield goal.
- Calculate a biosolids rate per acre by dividing crop N needs (pounds per acre) by PAN (pounds per dry ton).
- Apply biosolids only when the soil is not excessively wet, frozen or snow-covered, and when the application will not adversely affect the growing crop.
- Apply the waste away from streams, wells, dwellings and field boundaries next to property owned by others.
- Follow recommended best management practices.

## Resource

Missouri Department of Natural Resources, *Agricultural Use of Municipal Wastewater Sludge*. 1985.

This guide was previously named WQ430, *Crop/Nutrient Considerations for Biosolids.* The original author is James R. Brown, University of Missouri, School of Natural Resources.

## ALSO FROM MU EXTENSION PUBLICATIONS

EQ424 *Biosolids Standards for Pathogens and Vectors*
EQ426 *Best Management Practices for Biosolids Land Application*
EQ428 *Activity and Movement of Plant Nutrients and Other Trace Substances*
EQ429 *Interpretation of Laboratory Analysis of Biosolids Samples*

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