NCALC - A SOFTWARE PROGRAM FOR BALANCING MANURE RESOURCE USE

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Livestock producers know that manure can be applied to croplands as a soil amendment as well as a fertilizer. However, different animal sizes, handling systems, and cropping patterns complicate balancing manure nutrient application for the plants' benefit and for pollution control.

Oregon State University developed a software package for calculating appropriate manure application rates for particular crops and soil conditions. It also identifies losses of nutrients that can occur at different stages in the management and application system--from collection, through storage, to land application.

The values used in the program represent the best available knowledge for waste handling and crop growth over the statewide area. Specific values, such as from soil analyses, can be incorporated.

Benefits of manure fertilization

Increased crop production can result when you add the nutrients contained in manure. A manure slurry will also provide some water to the soil. Adding manure to soil can lessen wind and water erosion, improve soil aeration and tilth, increase soil organic matter, and promote the growth of microorganisms that are beneficial to crops.

Hazards in applying manure to crops

On the other hand, excess applications of manure can be harmful to crops, soil surface, and ground water quality. In some cases, most commonly with fresh poultry manure, high nitrogen content can burn crops. Heavy applications of manure also can cause excess accumulation of soluble salts in the soil, especially in arid regions, where little or no leaching occurs.

High salt content in soil can decrease water availability, which inhibits plant growth. In addition, a large volume of manure in one application can cause temporary soil sealing, particularly in low spots. Soil sealing increases the potential hazard of manure runoff with any subsequent rainfall.

Plant nutrients in manure

Studies have determined average production and nutrient content of fresh manures from farm animals. These studies are summarized in planning handbooks. Nutrient production of each animal species is calculated in NCALC based on values from the Midwest Plan Service publication "Livestock Waste Facilities Handbook (MWPS-18)."

For a portion of the year, the animals may spend part of a day in an area where the manure will be collected, and the rest of the day out on pasture. NCALC allows several handling systems and animal types to be calculated simultaneously. Any portion of the year up to 366 days can be calculated. A statement on the printout warns when less than a full year has been calculated.

Nutrient losses during collection and storage

Nutrient losses from manure occur in collection, during storage, while spreading, and after land application. These losses vary widely--under some conditions, up to 70 or 80% of the initial concentration will be lost. The type of animal housing and handling system also affects the final nutrient composition by influencing the addition of bedding, wastewater, and other materials.

Covered storage units generally are cooler and have less biological activity than open units. This usually means smaller losses from these units. Open storage units are subjected to precipitation resulting in leaching and runoff. Less nitrogen, for example, is lost from deep pits and roofed areas that are protected from high temperatures and rainfall.

Nitrogen is subject to the greatest losses of all the plant nutrients contained in manure. About 50% of the nitrogen in fresh manure is in the organic form and appears as partially digested feed and microorganisms. The other 50% is inorganic, usually as ammonia, and it's subject to significant losses during collection, storage, and application.

In most manure management systems, 5 to 15% of the original phosphorus and potassium is lost in handling. In open lots, however, as much as 50% of the phosphorus and 40% of the potassium can be lost through runoff and leaching.

In lagoon systems, up to 80% of the phosphorus and nitrogen can be lost. Much of the phosphorus is in the sludge along the bottom--and very difficult to remove in normal emptying operations.

The NCALC values for losses and untimate nutrient content represent the average of ranges acceptable for Oregon and are displayed or printed. The user cannot alter these values during data entry.

Nutrients removed from solids

Some operators use a liquid-solid separator to remove solids from the manure/wastewater slurry. If the solids (or any other part of the manure) are hauled off farm, NCALC subtracts that fraction from the amount of nutrients left to be applied

to the crop land. A separator is capable of removing solids containing about 22% of the nitrogen, and 20% of both phosphorus and potassium.

Nutrient losses during field application

Nitrogen can volatilize when manure is spread on cropland (fresh manure odor is mostly volatilized ammonia). Essentially all the phosphorus and potassium applied will be available for the crop. Runoff can remove a portion of all three nutrients; however, this type of loss is very site-specific and is not included in NCALC calculations.

Denitrification losses in the field

Nitrogen may also be lost by denitrification (loss of inorganic nitrogen by biological conversion to nitrogen gas). Anaerobic bacteria, which work in the absence of oxygen, break down nitrate nitrogen to release nitrogen gas; thus the more oxygen, the less nitrogen that is lost. This loss is related to the soil type and the rainfall pattern.

NCALC uses broad classifications of climate and soil types to develop five dinitrification values for Oregon. These again, are not changable by the user.

Availability of nutrients for crop requirements

Nitrogen is a vital nutrient, and its availability influences both microbial activity and plant growth. The carbon-nitrogen ratio (C/N) of applied wastes affects this availability and, therefore, affects plant growth.

If a material with a high C/N ratio, such as manure with a lot of bedding, is added to a soil, organisms that decompose the organic matter grow until limited by available minerals and nitrogen.

Inorganic nitrogen is the form that is taken up by the plant root system and used for growth. The organically bound nitrogen in the soil breaks down with time to form inorganic nitrogen. With enough time, the organic nitrogen present in manure will be converted to plant-usable inorganic nitrogen.

From 4 to 25% of the nitrogen in manure simply adds to the organic matter of the soil. This means that a fraction of the added manure won't be available for plant uptake.

This non-available fraction is sometimes referred to as the *recalcitrant* fraction. NCALC uses a value of 10% of the manure nitrogen as recalcitrant and adds 10% more nutrients to the crop requirements. This fraction won't add to surface or ground water pollution problems.

The breakdown process of manure is called *mineralization*. Since livestock feeds have various particle sizes and compositions, manures have different mineralization rates, and some of the manure may be in the soil 2 years before all the organic nitrogen is converted to plant-usable inorganic nitrogen. Therefore, not all the nitrogen contained in manure that has been incorporated into the soil can be used by the plants during the first year after manure application.

The rate of mineralization depends on the soil moisture content, organic matter level, and temperature. However, most animal manure is spread on the same fields year after year. Therefore, except for the recalcitrant component, the exact mineralization rate is unimportant because the plant will receive the same amount of nutrients each year after the first year--some from the current year's application, some from last year, and so on. This will be exactly the same amount next year.

NCALC assumes manure is applied to fields each year and no mineralization is accounted for in the calculations.

Management of the animals and crop is very important in determining proper application of manure on grass grown for forage. It's impossible to place a numerical value on the management factor, but NCALC assumes good management for best animal use in the harvested or grazed grass crops.

There are also different values for four different regions of Oregon. These represent differences in degree-day growing season and general soil types.
Because moisture availability is critical to grass production, the irrigated and non-irrigated choices reflect these levels of production.

Manure nutrients, especially nitrogen, are used more efficiently by grasses and cereals than by legumes. Inoculated legumes can get most of their nitrogen from the air, so additional nitrogen is not normally needed. However, NCALC will use manure nitrogen to satisfy legume crop requirements first.

A soil test showing specific fertilizer requirements for your crop can be used in NCALC. This option also allows a farmer to enter his or her own crop requirementsor to add a crop not among the 13 listed by NCALC.

Manure is not a balanced fertilizer for most crops. That is, it will contain higher proportions of one nutrient compared to the proportional requirements of the crop. NCALC calculates manure application two ways: for the least-needed nutrient and for nitrogen satisfaction. In most cases, if you apply manure at a rate to satisfy the nitrogen requirements, you'll over-apply phosphorus or potassium.

NCALC is a user-friendly aid for livestock producers to balance their manure nutrient resource with crop needs to minimize loss to ground or surface waters. The

calculated nutrient production is matched to the crop acreages and yields typical of the farm. If there is too much of any crop nutrient, after losses are accounted for, NCALC indicates the additional acreage or animal reduction required to balance the nutrient to the crops. A second printout shows appropriate animal numbers and acreage when manure nitrogen is the only concern.

The following pages are instructions for using NCALC and describe the options available.

NCALC manure resource balancer

NCALC can assist you in balancing plant nutrients from fresh or stored animal manures to the crops grown under different conditions in Oregon. These simplified steps in will get you started using NCALC on your IBM-compatible computer. If you have questions or problems with NCALC, call Mike Gamroth, OSU Extension Dairy Specialist at 737-3316 during business hours. Boldface in the instructions indicates input required.

1. Type NCALC (in caps or small letters) to start the program.

2. The masthead comes on the screen. Press any key to proceed with the program.

Throughout the program you will need to move around the screens to make entries. ↑ will move you up one line, ↓ moves you down one line, Tab or Enter moves you right one field, and Shift-Tab moves you left one field. → or ← only move you one space within the entry field.

3. Using the instructions above, highlight the animal species you will be working with. When highlighted, press the F2 key to proceed. You have an opportunity to enter other animal types later in the program.

4. Highlight "Printer and screen" if you have a printer and want a printed copy of the output. Your printer must send a carriage return with each line feed for a proper hardcopy of NCALC. Consult your printer manual about this feature. Highlight "Screen only" if you wish to work only on the computer monitor. Press the F2 key when the appropriate block is highlighted.

If you wish to change a selection, press the F9 key at any time to back up in the program and re-enter.

5. Highlight the handling method that most closely describes the farm method. Press **F2.** Some handling methods are not available for certain animals i.e. grazing for poultry. Highlight the associated manure application method for this system. Press F2. If you selected "Grazing" as a handling method, the program automatically selects "Grazing" as the application method.

6. Enter the number of this species of animals in the operation. Some hand calculation may be required. For example, if the operation's 100 dairy cows average 1,200 pounds weight, you should put 50 cows in the "1,000 lb" field and 50 cows in the "1,400 lb" field to calculate the most accurate manure nutrient production. Move down and enter the number of days this system will be used during the year (1 to 366 days). If you separate manure solids and haul them off the farm, answer Y to the final question. If you selected a system where a solids separator is not common, you can't move to this field and the answer will automatically be "N". When all of the information on this screen is correct, press F2.

7. The output you see on the screen is the manure and nutrients generated and saved by the animals and system you entered. Pressing F9 lets you go back and make changes in what you have done. Pressing F3 lets you add a different animal species, an additional manure handling and application system or the remaining days in the year when manure is handled differently. You may have as many systems, animal types, or periods of days (up to 366 days total for one species) as you desire. The manure nutrients will be totalled for application to crops. Pressing F2 proceeds to the crop input. The printer will print the output when F2 or F3 are pressed if you chose the "Printer and screen" option earlier.

8. Highlight the region of Oregon where the waste will be applied. Press F2. Enter the acres (as a whole number) grown in any of the thirteen crops listed. If several of the crops are not grown, just leave them blank. If none of the crops grown appear on this screen, press F3 and skip to #9.

After entering the acreage of each crop, enter the expected yield in tenths of a ton. For example, 10 or 1.0 will both be read as one ton. 250 or 25.0 will be 25 tons. You only need to enter acreage on pasture. There is no entry location for the yield.

Finally, if you put manure on certain crops before using it on others, you can tell the computer which crop to apply it to first (priority order 1), second (2), and so on. More than one crop can be in the same priority. This way the computer puts it on the "1's" first and, if there are manure nutrients remaining, it will apply them on the next crop(s). The priority order is optional. Without order stipulated, the computer will proceed down the list. When this screen contains the necessary information on the crops, press **F2** to proceed or press F3 to add additional crops not on the screen.

9. Adding additional crops (F3) requires a little more homework. This screen has room for three crops. Enter the name of the first crop. Press Enter. Now enter the pounds of nitrogen (N) required by each acre of the crop. You can take this from a soil test report or from your knowledge of what the crop truly requires for adequate production. If your entry is extremely high or low compared to what the crop uses, the usefulness of NCALC is limited. Press Enter. Now enter the pounds of phosphorus (P) required per acre. If your soil test report shows phosphate (P_2O_5) required, multiply that figure by

0.44 to get the phosphorus required. Press Enter. Enter the potassium (K) required (1 lb K_2O = 0.83 lb of K). Press Enter. Enter the acres of this crop. Press Enter. And enter the priority at which you would use manure on this crop (see previous paragraph). You may repeat this procedure for two more crops. When this screen is how you want it, press F2. If you want to return to the other crop screen, press F9.

10. The output shows the crop requirement of each nutrient per acre, how much was applied per acre in the manure, and the remaining pounds needed to fertilize the total acreage specified. The manure was applied so that no nutrient was over-applied. The rest of the output is self-explanatory. To change any item in the previous run (system type, animal numbers, crops grown, or acreage of each crop), press F9. While the animal numbers will be saved for the second run, you must re-enter each system type. If you're satisfied with the run and would like to run it again or if you want to exit the program, press F2. Again, the printer will run your hardcopy after all changes are made.

11. At the first screen press F10 to exit NCALC or begin with #3 to run again.

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