TECHNICAL NOTES

UNITED STATES DEPARTMENT OF AGRICULTURE — NATURAL RESOURCES CONSERVATION SERVICE
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AGRONOMY TECHNICAL NOTE NO. 92

ESTIMATING NUTRIENT REMOVAL/REPLACEMENT IN CROPS AND FORAGES

NRCS recommends that nutrients should be applied according to LSU Agricultural Center recommendations for optimal production and environmental protection. However, nutrient management plans can be based on replacement of N, P_2O_5, and K_2O removed annually in harvested biomass. Harvested biomass can take several different forms such as grazed forage, mechanically harvested forage, grain, vegetables, or fiber (seed cotton/lint or wood products).

Annual nutrient removal and replacement depends on the amount of biomass harvested (yield) and the nutrient content (% N, P, K) of the harvested biomass.

Yield depends on a number of variables, but for estimating annual removal and subsequent replacement of nutrients, we are primarily focused on the harvested portion of the crop or forage being grown and the harvest method. In a grazing system, harvest is accomplished with an animal that returns some to nearly all of the nutrients it consumes back to the soil surface through urine and feces. Compared to the total amount of forage consumed, nutrient removal may be rather small. Most of the P and K (80% - 90%) are recycled. The distribution of recycled nutrients is much better in rotationally grazed systems compared to continuously grazed systems. Nitrogen removal in grazing systems is greater than for P and K. Although large amounts of N are recycled, much of it is volatized. Nitrogen removal, in warm season grazing, under our climatic conditions is about 70%. Cool season nitrogen losses are about 30%. To accurately estimate nutrient removal in grazing systems, the planner must know the number of animals, their weight, daily and annual consumption, forage nutrient content, recycling percentages based on seasonal variations, and land area on which the forage is grazed so that removal/replacement can be estimated on a per acre basis. Nutrient removal/replacement for crops and mechanically harvested forages is much less complicated.

Nutrient content of harvested biomass is determined by analysis of the harvested portion of the crop or forage and is expressed as the percentage of N, P, and K in the harvested portion. Table 6-6, Chapter 6 of the Agricultural Waste Management Field Handbook (AWMFH) contains nutrient uptake data (percentages) for most of the crops grown in the U.S. Exhibit 4 of the conservation practice standard Waste Utilization (633), contains data pertinent to Louisiana and is expressed in pounds per acre (based on average yields).

Calculating nutrient removal/replacement is done by multiplying the yield (lbs/ac) by the percentage of nutrients in the harvested portion. Percentage is converted to a decimal by dividing the percent nutrients by 100 or simply moving the decimal point two places to the left.

The solution is pounds per acre of nutrients removed in the harvested portion of the crop or forage. The equations are the following:

Yield (lbs/ac) X %N/100 = _____ lbs of N removed per acre
Yield (lbs/ac) X %P/100 X 2.29* = _____lbs P_2O_5 removed per acre
Yield (lbs/ac) X %K/100 X 1.2 *= _____lbs K_2O removed per acre
(*Conversion factor for P to P_2O_5 and K to K_2O respectively)

In the presence of double cropping, nutrient removal rates should be determined for each crop and totaled. Where grain and stover are both harvested, nutrient removal rates should be determined for each component and totaled.

The following are three examples of estimating nutrient removal/replacement:

GRAZING SYSTEM
A producer is grazing 50 cows weighing 1000 lbs each on 100 acre of bahiagrass. The cows consume 2.6% of their body weight daily 365 days/year. The nutrient content of bahiagrass is 1.27% N, 0.13% P, and 1.73%K. 80% of the P and K and 30% of the N is recycled. Determine the amount of nutrients, in the fertilizer form, to replace those removed from this grazing system.

First, we must calculate the annual forage consumption. The equation is:
number of animals X weight/animal X 2.6% X 365 days/year = pounds of forage consumed annually, or 50 X 1000 X 0.026 X 365 = 474,500 lbs.

Next, we must determine the total amount of N, P, and K consumed annually. The equation is:
pounds of forage consumed annually X % N, P, and K in the forage, or
474,500 X 0.0127 = 6,026 lbs N consumed annually
474,500 X 0.0013 = 617 lbs P consumed annually
474,500 X 0.0173 = 8,209 lbs K consumed annually

Now, determine the amount of each nutrient removed annually. The equation is:
pounds of nutrients consumed X percent of nutrients removed, or
6,026 lbs N X 0.70 = 4,218 lbs N removed annually
617 lbs P X 0.20 = 123 lbs P removed annually
8,209 lbs K X 0.20 = 1,642 lbs K removed annually

Finally, we must determine removal per acre for purposes of replacement and then convert to the fertilizer form of the nutrient. The equation is:
pounds of nutrients removed annually/acreage grazed X conversion factor (NA for N), or
4,218 lbs N/100 = 42 lbs/ac N needed for replacement
123 lbs P/100 X 2.29 = 3 lbs/ac P_2O_5 needed for replacement
1,642 lbs K/100 X 1.2 = 20 lbs/ac K_2O needed for replacement

These are the minimum amounts of nutrients to be applied in this scenario. Actual grazing systems occur during both warm season and cool season. There might also be cool season forage involved, as well as, nutrients imported onto the farm in hay that is purchased. The automated spreadsheet takes all these factors into account and requires that you input a minimum amount of data.

Nutrient removal/replacement rates for nutrient such as phosphorus are quite small. It would be illogical to expect a producer to apply 3 pounds of P_2O_5 annually. However, if the producer is applying a mixed fertilizer to supply other nutrients, the amount of phosphate fertilizer required for replacement would more than likely be met without over applying soil test recommendations.

For instance, assume the producer in the above scenario chooses removal/replacement as his nutrient management alternative. He may accomplish this with the application of 17-17-17 @ 250 lbs/ac. This would meet his nitrogen needs and supply sufficient phosphate and potash as well.

HAYING SYSTEM

A producer harvests an average of 8 tons of hybrid Bermudagrass per acre from his commercial haying operation. The annual nutrient removal is calculated by multiplying the yield by the percentage of nutrients in the harvested portion of the hybrid Bermudagrass. The equation is:

yield X percent nutrients/100 = pounds of nutrients removed, or
16,000 lbs X 0.0188 N = 301 lbs/ac N needed for replacement
16,000 lbs X 0.0019 P X 2.29 = 70 lbs/ac P_2O_5 needed for replacement
16,000 lbs X 0.0140 K X 1.2 = 269 lbs/ac K_2O needed for replacement
(These are the minimum amounts of nutrients to be applied in this scenario.)

ROW CROP SYSTEM

A producer averages 90 bushels grain sorghum per acre on his farm which he sells as a cash grain crop. He also cuts and bales 3.5 tons of stover per acre and feeds to cows at another location. The annual nutrient removal is calculated by multiplying the yield by the percentage of nutrients in both the grain and the stover and adding them together. The equation is:

yield X percent nutrients (grain)/100 + yield X percent nutrients (stover)/100 = pounds of nutrients removed, or:
90 bu X 56 lbs/bu X 0.0167 N (grain) + 7,000 lbs X 0.0108 N (stover) = 160 lbs/ac N needed for replacement
90 bu X 56 lbs/bu X 0.0036 P (grain) + 7,000 lbs X 0.0015 (stover) X 2.29 = 58 lbs/ac P_2O_5 needed for replacement
90 bu X 56 lbs/bu X 0.0042 K (grain) + 7,000 lbs X 0.0131 K (stover) X 1.2 = 135 lbs/ac K_2O needed for replacement
(These are the minimum amounts of nutrients to be applied for this scenario.)

An excel spreadsheet (Nutrient mgmt removal rates.xls) is available for calculating nutrient removal rates for cropland, hayland, and grazing land.

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