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Estimating Nutrient Removal for Row Crops Grown in Arkansas

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Nutrient removal by the harvested portion of field crops (i.e., grain, silage, hay) is the primary pathway by which soil and fertilizer nutrients leave the field. The goal of effective nutrient management is to minimize nutrient losses to the environment while providing adequate nutrient availability to maximize crop nutrient uptake and ultimately yield. Understanding the differences between total nutrient uptake and nutrient removal in harvested portions of the grain or fiber crop is essential for nutrient management planning and profitable crop production in regard to soil fertilization. Valid estimates of nutrient removal rates should be based on sound research that is specific to regional production practices and uses realistic yield goals. Nutrient removal can vary widely from year to year and even from field to field, but can be useful in determining nutrient budgets and nutrient balances when done properly.

Estimating nutrient removal is an important part of a farm nutrient management plan. However, nutrient removal estimates do not provide adequate information to develop soil fertilization guidelines as they do not take into account the level of plant nutrients which are supplied by and retained within the soil. Crop nutrient removal estimates can be used in conjunction with soil-test levels to evaluate and develop fertilization programs, but nutrient removal should not be the sole basis for nutrient application and fertilization rates.

Nutrient Uptake vs. Nutrient Removal

Nutrient uptake is the total amount of nutrients taken up by the crop throughout the growing season and contained in the grain, leaves, stalks and roots. For most crops we typically only quantify total nutrient uptake in the aboveground portion of the plant biomass. Depending on the crop, a portion of these nutrients is returned to the soil in the form of crop residues (i.e., stalks, stubble, leaves) following harvest. Nutrient removal refers only to the nutrients contained in the portion of the crop that is harvested and removed from the field. The amount of nutrients removed from the field for crops harvested only for their grain is less than the total nutrient uptake because a portion of the nutrients remain in the crop residue. The nutrient harvest index for N and P is often quite high with

>75% of the total nutrients taken up removed in the harvested grain or fiber; whereas the nutrient harvest index for K and micronutrients is typically <50% of the total nutrient uptake. Crop residues will decompose over time and subsequently release the nutrients for successive crops.

Estimating Nutrient Removal

There are several ways in which nutrient removal can be estimated for row crops. The most common method is to use standard values for nutrient contents of major row crops and crop yield. Several sources of information provide reliable nutrient concentration values for crops and include the International Plant Nutrition Institute (IPNI) and the Plant Nutrient Content Database which was developed by the USDA Natural Resource Conservation Service (USDA-NRCS). These estimates typically provide a range of nutrient contents and are adapted from data collected over wide geographical regions and crop production practices. Table 1 provides estimates of nutrient removal common for selected Arkansas row crops. In addition to the table provided here and the many resources available, several companies have provided smartphone applications that can easily calculate nutrient removal based on yield per acre. These apps include, but are not limited to, (1) Crop Nutrient Removal Calculator by IPNI, (2) Nutrient Removal Calculator by A&L Labs, (3) Fertilizer Removal by Crop by Ag PhD and (4) Nutrient Removal by The Mosaic Company. Using these smartphone applications can make determining nutrient removal much simpler than hand calculations, and most of these apps draw their nutrient removal values from a common source. In addition to

Table 1. Estimated Nutrient Concentrations and Removal Rates in the Harvested Portion of Selected Arkansas Row Crops.

Crop (unit of measure)	Nutrient removal† (lb per unit of yield)			Yield (yield/acre)	Removal for given yield* (lb/acre)		
	N	P_2O_5	K_2O		N	P_2O_5	K_2O
Corn (bushels)	0.67	0.35	0.25	150	101	53	38
				200	134	70	50
				250	168	88	63
Cotton Lint (bale)	32	14	19	1	32	14	19
				2	64	28	38
				3	96	42	57
Grain Sorghum (bushels)	0.66	0.39	0.27	50	33	19	14
				100	66	39	27
				150	99	59	41
Rice (bushels)	0.57	0.30	0.16	150	86	45	24
				200	114	60	32
				250	143	75	40
Soybean (bushels)	3.3	0.73	1.2	30	99	22	36
				60	198	44	72
				90	297	66	108
Wheat (bushels)	1.2	0.48	0.29	30	36	14	9
				60	72	29	17
				90	108	43	26

†Data for nutrient removal obtained from International Plant Nutrition Institute (IPNI).
*Nutrient removal values rounded to the nearest whole number.

smartphone applications, there are many web-based calculators that can be accessed such as through IPNI (https://www.ipni.net/app/calculator/home) or the USDA-NRCS (http://plants.usda.gov/npk/main). Although these apps and software can simplify the process, please remember that these are only estimates and can only provide values for nutrient removal that are as good as the source of the data being used.

The best and most accurate way to determine nutrient removal is to collect representative grain samples and have them analyzed. Many labs can provide this service including the University of Arkansas Diagnostic Lab located in Fayetteville, Arkansas. Reports for nutrient content are often expressed on a dry weight basis as either a percentage or concentration (i.e., mg nutrient/kg biomass, ppm or percentage). To accurately determine nutrient removal, the dry weight values need to be adjusted to the harvest moisture content of the crop. Differences in moisture content of the grain prior to analysis can lead to slight differences in the estimated nutrient removal, but are typically less than 5% error. Example 1 below provides a template to determine crop nutrient removal from rice grain that contains 0.3% P on a dry weight basis.

Based on Example 1, the nutrient removal per area basis is 23.4 lbs P/acre (elemental P) using the dry weight conversion from a laboratory analysis report and actual yield data.

For phosphorus (P) and potassium (K) it is useful to understand the difference between the elemental (P and K) and oxide (P_2O_5 and K_2O) nutrient expressions. The oxide nutrient forms are used for expressing fertilizer analysis (e.g., 18-46-0, N-P_2O_5-K_2O) and application rates, whereas lab tissue or seed analysis reports often provide nutrient concentrations on an elemental basis as %P and %K. To convert elemental P and K concentrations to P_2O_5 and K_2O, respectively, use the formulas listed below.

$$\% P_2O_5 = \%P \times 2.29$$
$$\% K_2O = \%K \times 1.205$$

To convert the elemental P removed in the previous example to a fertilizer (P_2O_5) basis:

$$\frac{23.4 \text{ lbs P}}{\text{acre}} \times 2.29 = 53.6 \text{ lbs } P_2O_5/\text{acre}$$

When you are unable to determine the exact nutrient content of harvested grain using laboratory analysis, reliable sources can be used as estimates. Estimating nutrient values using Table 1 is presented in Example 2 on the next page, where we will determine the K_2O removed in a 220-bushel corn crop.

Example 1: Estimating P removal in rice grain using a lab report.

$$\frac{0.3 \text{ lbs P}}{100 \text{ lbs dry rice grain}} \times \frac{0.875 \text{ lbs dry rice}}{1 \text{ lb rice grain}} = 0.0026 \text{ lbs P/lb of rice grain}$$

Converting crop nutrient removal to standard test weight, which for rice is 45 lb/bushel.

$$\frac{0.0026 \text{ lbs P}}{1 \text{ lb rice grain}} \times \frac{45 \text{ lbs rice grain}}{1 \text{ bushel rice grain}} = 0.117 \text{ lbs P/bushel of rice grain}$$

Determining crop nutrient removal on an area basis.

$$\frac{0.117 \text{ lbs N}}{\text{bushel of rice grain}} \times \frac{200 \text{ bushels rice grain}}{\text{acre}} = 23.4 \text{ lbs P/acre}$$

Example 2: Estimating K_2O removal in corn grain using nutrient removal estimates.

$$\frac{0.25 \text{ lbs } K_2O}{\text{bushel corn grain}} \times \frac{220 \text{ bushels corn grain}}{\text{acre}} = 55 \text{ lbs } K_2O/\text{acre}$$

Summary

Crop nutrient removal can be determined and estimated using the procedures outlined in this publication. However, it should be noted that nutrient management planning or estimates of nutrient removal should not be the sole source for determining crop fertilization needs. Soil tests should be taken regularly and be used in conjunction with estimates of nutrient removal to guide nutrient management decisions. Routine soil tests can also ensure that soil fertility levels are not drastically changing over both short- and long-time scales. Estimates of crop nutrient removal and nutrient balances (fertilization – crop removal) cannot take into account all of the inputs and outputs that occur for a field. However, when done properly and coupled with soil-test data, nutrient removal estimates can be useful in guiding fertilization programs and reducing the potential for nutrient loss to the environment.

References and Literature of Interest

IPNI. 2012. IPNI Estimates of nutrient uptake and removal. (http://www.ipni.net/article/IPNI-3296, 5 January 2014). International Plant Nutrition Institute, Peachtree Corners, Georgia 30092-2844.

IPNI. 2012. 4R Plant Nutrition: A manual for improving the management of plant nutrition. International Plant Nutrition Institute, Peachtree Corners, Georgia 30092-2844.

USDA, NRCS. 2012. The PLANTS Database (http://plants.usda.gov, 5 January 2014). National Plant Data Team, Greensboro, North Carolina 27401-4901.

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