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Nitrogen Removal by Delaware Crops

Amy L. Shober

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Introduction

Effective nutrient management minimizes nutrient losses to the environment while maximizing the crop nutrient uptake. Valid numbers for all nutrient inputs and outputs are required to most effectively manage nutrients in agronomic and vegetable crop systems. The amount of nitrogen (N) removed by the harvested portion of the crop is needed to develop nutrient balances. However, N removal by crops can vary considerably from field-to-field and year-to-year. The purpose of this document is to provide average values of N uptake for common Delaware grain, forage, and vegetable crops for use in nutrient management planning activities.

What is "Crop Nutrient Removal"?

Crop nutrient removal is defined as the total amount of nutrients removed from the field in the harvested portion of the crop (e.g., grain, silage, hay). The term crop nutrient removal should not be confused with crop nutrient uptake, which is defined as the total amount of nutrients contained in the entire crop at maturity. For example, this would include N in the grain, stover, and roots of a corn crop. Crop nutrient removal is lower than crop nutrient uptake because a significant percentage of the nutrients taken up by a crop are returned to the soil in the form of crop residues. Nutrients remaining in crop residues are subsequently available for uptake by crops planted in the next season.

Determining Crop Nitrogen Removal for Delaware Crops

Removal of N by crops can be estimated using standard values for the N content in the harvested portion of the crop and crop yield. The USDA Natural Resources Conservation Service (NRCS) Crop Nutrient Uptake Tool (part of the PLANTS Database at https://plants.usda.gov/) provides standard values for estimating N removal for Delaware crops. However, the most accurate way to determine crop N removal is to have a representative sample of the harvested portion of the crop analyzed for N content. Analyzing crop samples for nutrient removal is different from routine plant tissue analysis, which is used to monitor the nutrient content of a crop or to identify nutrient deficiency or toxicity. For example, a subsample of the harvested grain that is collected from the combine or weigh wagon after yield determination is analyzed for N content to quantify N removal at harvest. In contrast, analysis of ear leaf samples collected at initial silking is useful to monitor corn nutrient content during the growing season. For vegetable crops, the use of standard values for N content may be preferable to harvested tissue analysis due to the difficulty encountered when trying to dry vegetables. Because of their high water content, a freeze drier is often required to prevent the vegetable samples from rotting during drying.

Laboratory nutrient analysis reports usually provide nutrient content of plant tissue samples on a dry weight basis (i.e., units of nutrient per unit of dry plant tissue). To determine crop N removal, these dry weight values must be adjusted to account for the moisture content of the crop. In addition, for crops where yield is reported in units other than pounds per acre, the N content of the harvested tissue must be adjusted based on the weight per unit (such as pounds per bushel).

The following example illustrates how to determine crop N removal for corn grain containing 1.45% N based on results of lab analysis:

This value corresponds to 1.45 lb N per 100 dry lb of corn grain. Because this value is listed on a dry weight basis, it must be adjusted to account for the moisture content of the crop. For corn grain, if we assume a moisture content of 15.5%, which is equivalent to 84.5% dry matter or 0.845 lb dry corn grain per lb corn grain:

$$\frac{1.45\ lb\ N}{100\ lb\ dry\ corn\ grain} \times \frac{0.845\ lb\ dry\ corn\ grain}{1\ lb\ corn\ grain}$$

$$= 0.0123\ lb\ N/lb\ corn\ grain$$

Crop N removal must then be adjusted (when applicable) based on the standard test weight. The standard test weight for corn grain is 56 lb/bu:

$$\frac{0.0123\ lb\ N}{1\ lb\ corn\ grain} \times \frac{56\ lb\ corn\ grain}{1\ bu}$$

$$= 0.689\ lb\ N/bu$$

Therefore, the actual nutrient removal for corn grain in this example would be 0.69 lb N per bushel.

Nitrogen Removal by Typical Delaware Crops

The N removal rates for typical Delaware grain crops listed in this document were determined by analyzing the harvested portion of selected crops in Delaware (Binford, 2008). Between 2003 and 2007, a total of 668 corn grain samples, 175 soybean samples, 322 winter wheat samples, and 117 winter barley samples were collected at harvest from locations throughout Delaware (with a small number of samples collected from farms located on the eastern shore of Maryland that share similar climate, soil, and cropping conditions as Delaware) and analyzed for N content (Binford, 2008). Nitrogen content of harvested grain samples in Delaware reported by Binford (2008) was comparable to standard values reported in the USDA-NRCS Crop Nutrient Removal database.

Only a small number of vegetable and forage harvest samples were collected from Delaware fields in 2004 due to issues related to drying samples for analysis. Nitrogen values in harvested tissue of the vegetable and forage crops data presented by Binford (2008) were in good agreement with values obtained from the USDA-NRCS Crop Nutrient Uptake Tool. Therefore, standard values for crop N removal of selected vegetable and forage crops from the USDA-NRCS Crop Nutrient Uptake Tool are reported in this publication. We then calculated the amount of N removed per acre by grain and forage crops (Table 1) and vegetable crops (Table 2) over a range of realistic yield goals for major Delaware crops, where removal is the product of N content and crop yield.

Table 1. Estimated Nitrogen Removal in the Harvested Portion of Selected Delaware Grain and Forage Crops.

Crop	Yield Unit	Crop N Content (lb N /yield unit)	Yield (yield unit/ac)	Crop N Removal (lbs/ac)
Barley	bu (48 lbs/bu @ 14% moisture)	0.76	40	30
			60	46
			80	61
			100	76
Corn	bu (56 lbs/bu @ 15.5% moisture)	0.69	50	35
			100	69
			150	104
			200	138
Soybean	bu (60 lbs/bu @ 13% moisture)	3.44	30	103
			40	138
			50	172
			60	206
Wheat	bu (60 lbs/bu @ 13% moisture)	1.05	40	42
			60	63
			80	84
			100	105
Corn silage	ton (@ 70% moisture)	7.75	15	116
			20	155
			25	194
			30	233
Grass-legume hay	ton (@12% moisture)	43.6	2	87
			3	131
			4	174
			5	218

Table 2. Estimated Nitrogen Removal in the Harvested Portion of Selected Delaware Vegetable Crops.

Crop	Yield Unit	Crop N Content (lbs N/yield unit)	Yield (yield unit/ac)	Crop N Removal (lbs/ac)
Bell pepper, fresh market	boxes (25 lbs/box @ 92.5% moisture)	0.04	750	30
			1000	40
			1250	50
			1500	60
Bell pepper processing	lbs (@ 92.5% moisture)	0.002	18000	36
			21000	42
			23000	46
			26000	52
Cantaloupe	melons (6 lbs/melon @ 96% moisture)	0.009	3500	32
			5000	45
			6500	59
			8000	72
Cabbage	cwt (@ 91% moisture)	0.32	100	32
			115	37
			120	38
			125	40
Cucumber, pickler processing	bu (50 lbs/box @ 95.5% moisture)	0.055	150	8
			200	11
			250	14
			300	17
Eggplant	boxes (32 lbs/box @ 93% moisture)	0.058	700	41
			800	46
			900	52
			1000	58
Jalapeno pepper	lbs (@ 92% moisture)	0.002	25000	50
			30000	60
			35000	70
			40000	80
Lima bean	lbs (@ 69% moisture)	0.011	1000	11
			2000	22
			3000	33
			4000	44
Peas	cwt (@ 79% moisture)	0.94	15	14
			25	24
			35	33
			45	42
Potatoes	cwt (@ 77.2% moisture)	0.37	150	56
			200	74
			250	93
			300	111

Table 2 (Continued). Estimated Nitrogen aware Vegetable Crops.

Crop	Yield Unit	Crop N_5 Content (lbs N/yield unit)	Yield (yield unit/ac)	Crop N Removal (lbs/ac)
Sweet corn, processing	tons (@ 75% moisture)	8	4	32
			6	48
			8	64
			10	80
Squash, fresh market	boxes (20 lbs/box @ 95% moisture)	0.038	550	21
			600	23
			650	25
			700	27
Squash, processing	lbs (@ 95% moisture)	0.002	12500	25
			15000	30
			17500	35
			20000	40
Tomato	boxes (25 lbs/box @ 94% moisture)	0.038	750	29
			900	34
			1050	40
			1200	46
Watermelon	lbs (@ 91% moisture)	0.001	45000	45
			60000	60
			75000	75
			90000	90

Based on calculated N removal rates for Delaware crops, growers can estimate the amount of N removed in a planned crop rotation. The following are examples of estimated N removal for some common Delaware cropping systems.

System #1: Corn-Wheat/Soybean-Corn, Dryland

Year	Crop	Yield	Crop N Removal (lb/ac)
1	Corn	150 bu/ac	104
2	Wheat Soybean	70 bu/ac 35 bu/ac	74 120
Rotational Crop Removal			**298**

System #2: Corn-Wheat/Soybean-Corn, Irrigated

Year	Crop	Yield	Crop N Removal (lb/ac)
1	Corn	275 bu/ac	190
2	Wheat Soybean	90 bu/ac 55 bu/ac	95 189
Rotational Crop Removal			**474**

System #3: Corn-Full Season Soybean

Year	Crop	Yield	Crop N Removal (lb/ac)
1	Corn	225 bu/ac	155
2	Soybean	60 bu/ac	206
Rotational Crop Removal			**361**

System #4: Grain Crops and Vegetables

Year	Crop	Yield	Crop N Removal (lb/ac)
1	Corn	150 bu/ac	104
2	Wheat Soybean	70 bu/ac 35 bu/ac	74 120
3	Peas Lima Beans	30 cwt/ac 2,500 lbs/ac	28 28
Rotational Crop Removal			**354**

Summary

The amount of N removed in the harvested portion of the crop can be determined using the standard crop removal values and the procedures presented above or by analyzing the N content of the harvested portions of the crop. If direct analysis is selected, one should keep in mind that results can be highly variable by field and year and difficult to perform for vegetable crops due to their high moisture content. Once crop N removal is determined, those removal rates can be used in subsequent nutrient management planning as part of an adaptive N management approach to determine the appropriate amounts of N to apply to a particular cropping system to maximize uptake and minimize losses to the environment.

References

Binford, G. 2008. Nutrient removal rates for common crops in Delaware: Final report. Submitted to the Delaware Center for the Inland Bays. University of Delaware. Newark.

USDA, NRCS. 2025. The PLANTS Database (http://plants.usda.gov, 3 March 2025). National Plant Data Team, Greensboro, NC 27401-4901 USA.

About the Authors

Amy L. Shober (corresponding author), Professor and Extension Specialist, University of Delaware, Newark, DE (ashober@udel.edu)

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Peer Reviewers

Sydney Riggi, Extension Agent, University of Delaware Cooperative Extension, Dover, DE

Jennifer Volk, Extension Specialist, University of Delaware Cooperative Extension, Dover, DE