

Updating Values of Prairie Crop Nutrient Uptake and Removal: Part 1

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Background:

Nutrient uptake (in whole plant) and removal (in grain) are useful values in planning and managing soil fertility practices, such as:

- phosphorus (P) recommendations to build, maintain or drawdown soil test levels into a medium-high range
- manure management planning

General values published by Canadian Fertilizer Institute (CFI) in 2001 were prior to hybrid canola and with lower crop yields than present (Figure 1). An updated version from International Plant Nutrition Institute (IPNI) summarizes values, but may not be relevant to the Prairies (ie canola Fig 2).

This prompted a small sampling of crops to evaluate relevance of these published values.

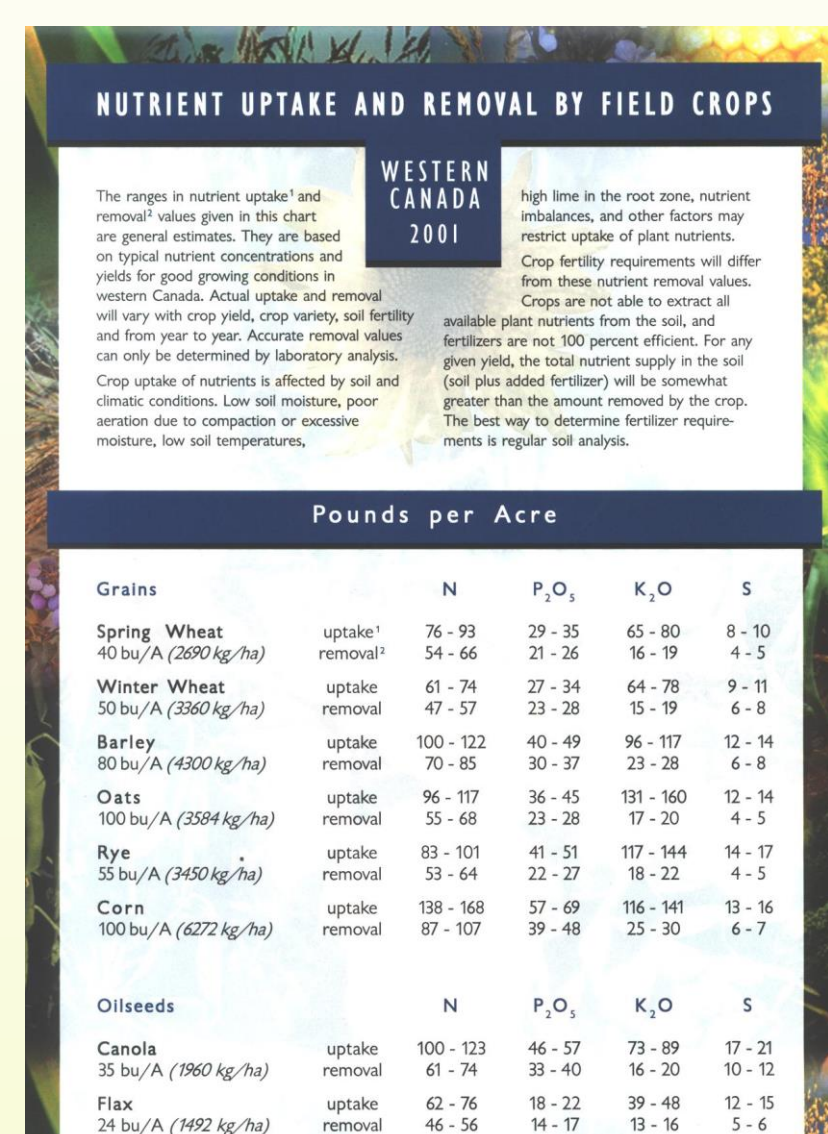


Figure 1. Nutrient Uptake and Removal for Western Canada Crops, 2001.

Imperial/U.S. Unit Tables

Table 4.1 Total nutrient uptake* by selected crops (last modified: May 2014).

Crop***	Region	Harvested Unit	—lb uptake/harvested unit**				
			N	P ₂ O ₅	K ₂ O	S	
Alfalfa (DM)	Argentina	ton	54	11	50	7.0	
Berly	Argentina	bu	3.3	0.64	3.1	0.2	
Bermudagrass	USA	ton	46	12	50		
Canola	China	bu	2.2	1.4	4.4		
Canola	India	chf	4.6	0.84	4.9		
Corn	USA	bu	1.0	0.54	1.4		
Grain	China	ton	11	10	17		
Maize	China	ton	3.3	1.5	1.1	1.4	
Maize	India	chf	5.3	1.6	7.2		
Orange	China	ton	9.2	3.2	10		
Peanut	India	ton	126	23	74	7.8	
Peanut	China	ton	10	4.0	10		
Peas, green	India	ton	84	29	60	8.6	
Potato	Australia	chf	0.49	0.21	1.2		
Rice	USA	bu	0.71	0.39	1.1		
Soybean	India	chf	3.9	0.84	2.2	1.3	
Soybean	USA	bu	2.2	1.3	3.4		
Soybean	China	bu	4.9	1.1	2.3		
Soybean	China	ton	9.2	2.8	10		
Sugarcane	China	ton	3.6	0.72	4.2		
Sunflower	Argentina	chf	4.0	2.5	3.5	0.50	
Tobacco	China	chf	3.9	1.2	7.1		
Tomato	India	ton	5.6	2.6	7.6		
Wheat, spring	USA	bu	2.2	0.76	1.5		
Wheat, winter	USA	bu	1.9	0.69	2.0		

* Total nutrient uptake refers to the quantity of nutrient accumulated in the above ground portion, and harvested portions, of the plant by the time of sampling, usually physiological maturity or when uptake is at its maximum.
 ** Reported nutrient uptake coefficients may vary regionally depending on growing conditions. Use locally available data whenever possible.
 *** DM = dry matter basis; otherwise moisture content is standard marketing convention or at the stated moisture content.
 Last modified: May, 2014.

Figure 2. Nutrient uptake and removal for IPNI, 2014 <http://www.ipni.net/article/IPNI-3296>

Method:

Sampled corn, oats, wheat soybeans and canola at 2 times – at full biomass production to determine whole plant uptake (including fallen leaves of canola, soybeans) and then harvested grain for removal. Samples were dried, ground and then analysed by AgVise Laboratories.

- Canola = 6 sites (n=12), 3 BASF demos, 2 MARD research sites, 1 farm field
- Soybeans = 5 sites (n=16), 3 SeCan sites, 1 MARD research sites, 1 farm
- Oats = 3 sites (n=6), McVet sites
- CNHR Wheat = 8 sites (n=22), 3 SeCan sites, 3 McVet sites, 2 farms
- Corn = 7 sites (n=20), 5 MCGA on-farm-test, 2 farm field sites



Table 1. Whole plant biomass sampling to determine crop nutrient uptake.

Results:

- For planning purposes, it is preferred to report nutrient uptake and removal by the yield component (bu) produced, so that growers can tailor for their actual and target yields.
- Grain yields of the crops varied as did harvest index (the % grain weight/biomass weight). Stress that reduced yield, reduced harvest index.
- Table 1 reports study results (mean, standard deviation and range) and contrasts to average CFI and IPNI values.
- Nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) values within 10%, 20% or >20% of CFI values are in cells coloured green, yellow and pink, respectively.

Table 1. Canola nutrient uptake and removal (lb/bu* and g/bu for micronutrients**).

	Uptake (biomass)					Removal (grain)						
	CFI	IPNI	MB	St	Range	CFI	IPNI	MB	St	Range		
	Ave	Ave	Ave	Dev	Low	High	Ave	Ave	Ave	Dev	Low	High
N*	3.2	2.2	3.6	0.7	2.7	4.9	1.93	1.6	2.1	0.7	1.8	2.2
P ₂ O ₅ *	2.94	1.4	1.1	0.3	0.64	1.48	1.04	0.8	0.7	0.2	0.53	1.0 M
K ₂ O*	2.31	4.4	3.2	1	1.43	4.64	0.51	0.4	0.4	0.9	0.3	0.47 M
S*	0.54		0.8	0.2	0.57	1.27	0.31	0.25	0.2	0.2	0.19	0.24
Ca*			0.7	0.4					0.2	0.5		
Mg*			1.9	0.3					0.2	0.2		
B**			2.2	0.4					0.3	0.6		
Cu**			0.2	0					0.1	0		
Fe**			14.6	7.7					1.5	4.4		
Mn**			2.4	0.9					0.8	0.5		
Zn**			1.3	0.3					0.8	0.3		

- Canola yields averaged 46.9 bu/ac (40-56 bu/ac range).
- Uptake and removal of P was much less than the CFI values.
- K uptake was greater than CFI values (but less than IPNI). A wide range in K uptake values is not unexpected due to luxury uptake.
- S uptake was greater and S removal was less than CFI values.
- The manured site (M) had the greatest values of P and K removal.

Table 2. Soybean nutrient uptake and removal (lb/bu* and g/bu for micronutrients**). Note: soybeans not included in CFI Western Canada chart, so used Eastern Canada values.

	Uptake (biomass)					Removal (grain)						
	CFI	IPNI	MB	St	Range	CFI	IPNI	MB	St	Range		
	Ave	Ave	Ave	Dev	Low	High	Ave	Ave	Ave	Dev	Low	High
N*	5.2	4.9	5.38	2.1	3.8	11 D	3.87	3.3	2.92	0.2	2.6	3.2
P ₂ O ₅ *	0.9	1.10	1.15	0.4	0.7	1.8 D	0.84	0.73	0.65	0.1	0.49	0.83
K ₂ O*	3.4	2.30	3.27	1.3	1.3	6.0 D	1.40	1.2	1.06	1.06	0.1	0.88
S*	0.34	-	0.46	0.1	0.25	0.75	0.10	0.18	0.15	0.0	0.13	0.17
Ca*			2.2	0.6					0.1	0.0		
Mg*			2.0	0.9					0.2	0.0		
B**			3.6	1.2					0.7	0.1		
Cu**			0.5	0.2					0.2	0.0		
Fe**			54.4	49.8					1.6	0.2		
Mn**			4.9	1.3					0.6	0.1		
Zn**			1.7	0.6					0.7	0.2		

- Soybean yields averaged 34.6 bu/ac (12-63 bu/ac range)
- The site with lowest yields due to drought (D) had low harvest index which inflated biomass removal measures per bu for N, P and K.
- P uptake was greater but P removal was less than CFI values.

Summary:

- Yields measured were 22-72% greater than the original CFI chart and many macronutrient values differed by more than 20%.
- Measured P removal per bu was less than CFI values for canola, soybean and corn and could impact fertilization based on balancing input and removals.
- When yields were reduced by drought or frost, inflated nutrient uptake per bu values resulted. In canola, a manured site had the highest removal of P and K.

Part 2: A Prairie-Wide Survey

- A Prairie-wide survey of nutrient removal values by 14 crops is currently underway through cooperation of University of Saskatchewan (F. Walley), Nutrien (L. Cowell) and MARD (J Heard).
- 50-200 samples of each crop from farm fields (not research plots) were collected (along with information on yield and fertilizer application) and will be analysed to update Prairie crop removal values.

Table 3. CNHR wheat nutrient uptake and removal (lb/bu* and g/bu for micronutrients**).

	Uptake (biomass)					Removal (grain)						
	CFI	IPNI	MB	St	Range	CFI	IPNI	MB	St	Range		
	Ave	Ave	Ave	Dev	Low	High	Ave	Ave	Ave	Dev	Low	High
N*	2.11	2.2	2.11	0.47	1.4	2.9	1.5	1.5	1.59	0.14	1.31	1.73
P ₂ O ₅ *	0.8	0.76	0.59	0.15	0.4	0.93	0.6	0.59	0.50	0.06	0.37	0.63
K ₂ O*	1.8	1.5	1.43	0.40	0.85	2.46	0.43	0.33	0.23	0.03	0.19	0.28
S*	0.23	-	0.17	0.03	0.11	0.25	0.11	0.1	0.09	0.01	0.07	0.10
Ca*			0.2	0.1					0.0	0.0		
Mg*			0.3	0.1					0.1	0.0		
B**			0.3	0.1					0.0	0.0		
Cu**			0.2	0.1					0.1	0.0		
Fe**			3.8	1.3					1.1	0.2		
Mn**			2.0	1.0					0.9	0.3		
Zn**			0.7	0.3					0.6	0.2		

- Wheat yields averaged 69 bu/ac (48-93 bu/ac range).
- Uptake was less than CFI values for P, K and S, as was removal of K.

Table 4. Oat nutrient uptake and removal (lb/bu* and g/bu for micronutrients**).

	Uptake (biomass)					Removal (grain)						
	CFI	IPNI	MB	St	Range	CFI	IPNI	MB	St	Range		
	Ave	Ave	Ave	Dev	Low	High	Ave	Ave	Ave	Dev	Low	High
N*	1.17		1.05	0.26	0.81	1.45	0.62	0.92	0.66	0.08	0.6	0.82
P ₂ O ₅ *	0.4		0.29	0.05	0.22	0.34	0.25	0.28	0.24	0.06	0.17	0.33
K ₂ O*	1.15		1.22	0.32	0.7	1.64	0.19	0.19	0.17	0.02	0.15	0.20
S*	0.13		0.11	0.04	0.06	0.17	0.05	0.07	0.05	0.01	0.05	0.06
Ca*			0.1	0.0					0.0	0.0		
Mg*			0.2	0.1					0.1	0.0		
B**			0.2	0.1					0.1	0.0		
Cu**			0.1	0.0					0.1	0.0		
Fe**			2.3	1.4					0.7	0.2		
Mn**			1.2	0.8					0.5	0.2		
Zn**			0.4	0.1					0.3	0.1		

- Oat yields averaged 122 bu/ac (113-142 bu/ac range).
- Uptake was less than CFI values for P. Other values were similar.

Table 5. Corn nutrient uptake and removal (lb/bu* and g/bu for micronutrients**).

	Uptake (biomass)					Removal (grain)						
	CFI	IPNI	MB	St	Range	CFI	IPNI	MB	St	Range		
	Ave	Ave	Ave	Dev	Low	High	Ave	Ave	Ave	Dev	Low	High
N*	1.53	1.0	1.42	0.44	0.9	2.1 F	0.97	0.67	0.63	0.07	0.54	0.78
P ₂ O ₅ *	0.63	0.54	0.40	0.11	0.28	0.58 F	0.44	0.35	0.25	0.07	0.19	0.38
K ₂ O*	1.29	1.4	1.01	0.38	0.56	1.75 F	0.28	0.25	0.18	0.04	0.16	0.25
S*	0.15	-	0.09	0.02	0.07	0.14 F	0.07	0.08	0.04	0.01	0.03	0.05
Ca*			0.17	0.04					0.0	0.0		
Mg*			0.27	0.06					0.06	0.01		
B**			0.20	0.05					0.06	0.02		
Cu**			0.11	0.03					0.02	0.01		
Fe**			11.6	3.0					0.33	0.07		
Mn**			1.4	0.40					0.08	0.03		
Zn**			1.14	0.37					0.27	0.03		

- Corn yields averaged 137 bu/ac (103-163 bu/ac).
- The site with lowest yields due to early frost (F) had low harvest index which inflated biomass removal per bu measures for N, P, K and S.