Nutrient Uptake and Modern Hemp Cultivars

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MB Agriculture
Analyses provided by:
Hemp Genetics International (HGI)

Manitoba

A farmer testimonial that hemp needs nutrients:
“We variable rate our conventional fertilizer, but this field also had some hog manure that you can easily pick up the direction and misses of the applicator.”

So what are nutrient needs of Hemp?

- New cultivars? Dual purpose or seed?
- Where do fertility recommendations come from?
- Is there “mature agronomy” in this crop?

Developing fertilizer recommendations

- Need a robust data set
- Low variability
- High yield potential
- Range of soil test values

- Or borrow recommendations, data from elsewhere
- Or base recommendations on crop uptake and removal

Where is the soil fertility data?

- Some published work from Saskatchewan and Quebec
- Little published in MB – most in “grey literature”
- Many still developing recommendations based on crop uptake and removal data
- Our 2007 poster still quoted by US sources

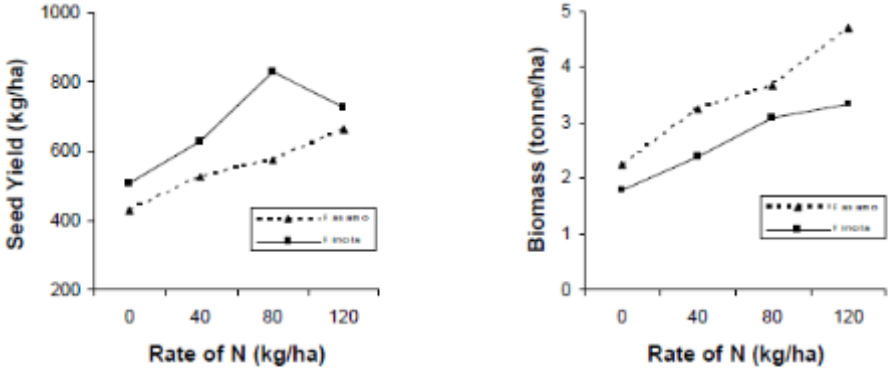


Figure 2. Effect of N fertilizer rate on seed yield and biomass production of hemp cv. Fasamo and Finola at Melfort in 2000 and 2001.

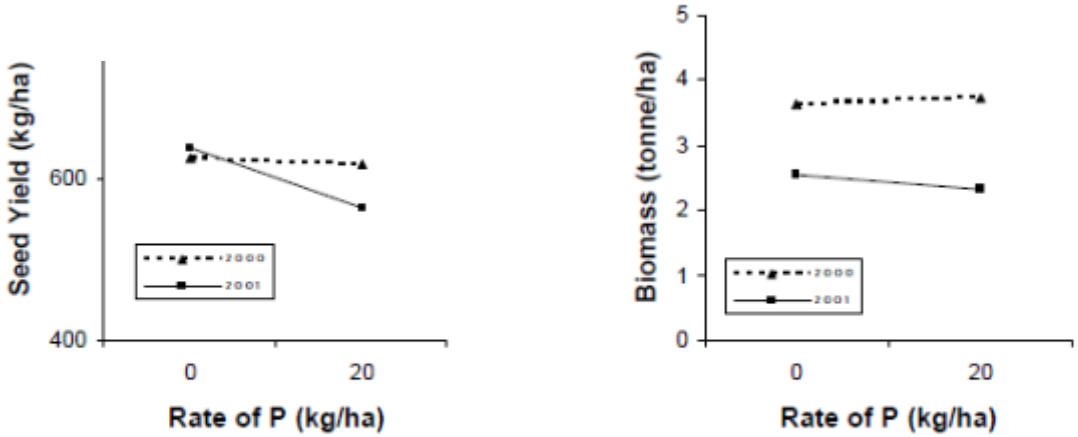


Figure 3. Effect of P fertilizer rate on seed yield and biomass production of hemp at Melfort in 2000 and 2001 (average of two cultivars).

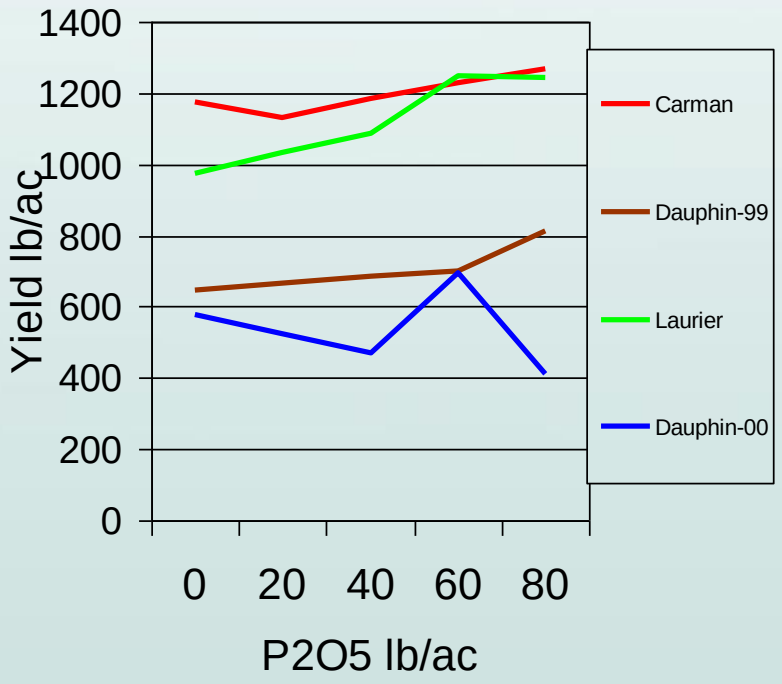
How Hungry is Hemp for Fertilizers?

C.L. Vera, S.S. Malhi, G.J. Moskal and D.W. Leach

http://www.usask.ca/soilsncrops/conference-proceedings/previous_years/Files/2002/2002_DOCS/Vera(2)_2002.pdf

Manitoba studies (pre 2000)

- Yield differences with added phosphate were not significant.
- Yield response trends were modest
- Most studies were located on high fertility sites



Reviews

Station Bulletin 681
May 1998

Feasibility of
Industrial Hemp Production
in the United States
Pacific Northwest

Agricultural Experiment Station
Oregon State University

Table 3. Hemp fertilization rates.

Country	Year	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
United States	1952	60	30	40
Spain	1955	60	100	70
Italy	1956	40-60	100	70
Netherlands	1957	100-200		
Rumania	1961	50-70	30-60	
Bulgaria	1964	120	90	60
Netherlands	1964	120	80	160-180
USSR	1965	150	90	120
Netherlands	1966	120	100	100
USSR	1966	120	90	90
Rumania	1966	50	100	
USSR	1968	120	90	90
South Korea	1968	100	60	80
USSR	1969	120	90	90
Italy	1975	75-150		
Denmark	1976	140		
France	1982	100-140	80-120	160-200
Poland	1995	90-120	70-100	150-180
United Kingdom	1995	120	100	160

100-150 N

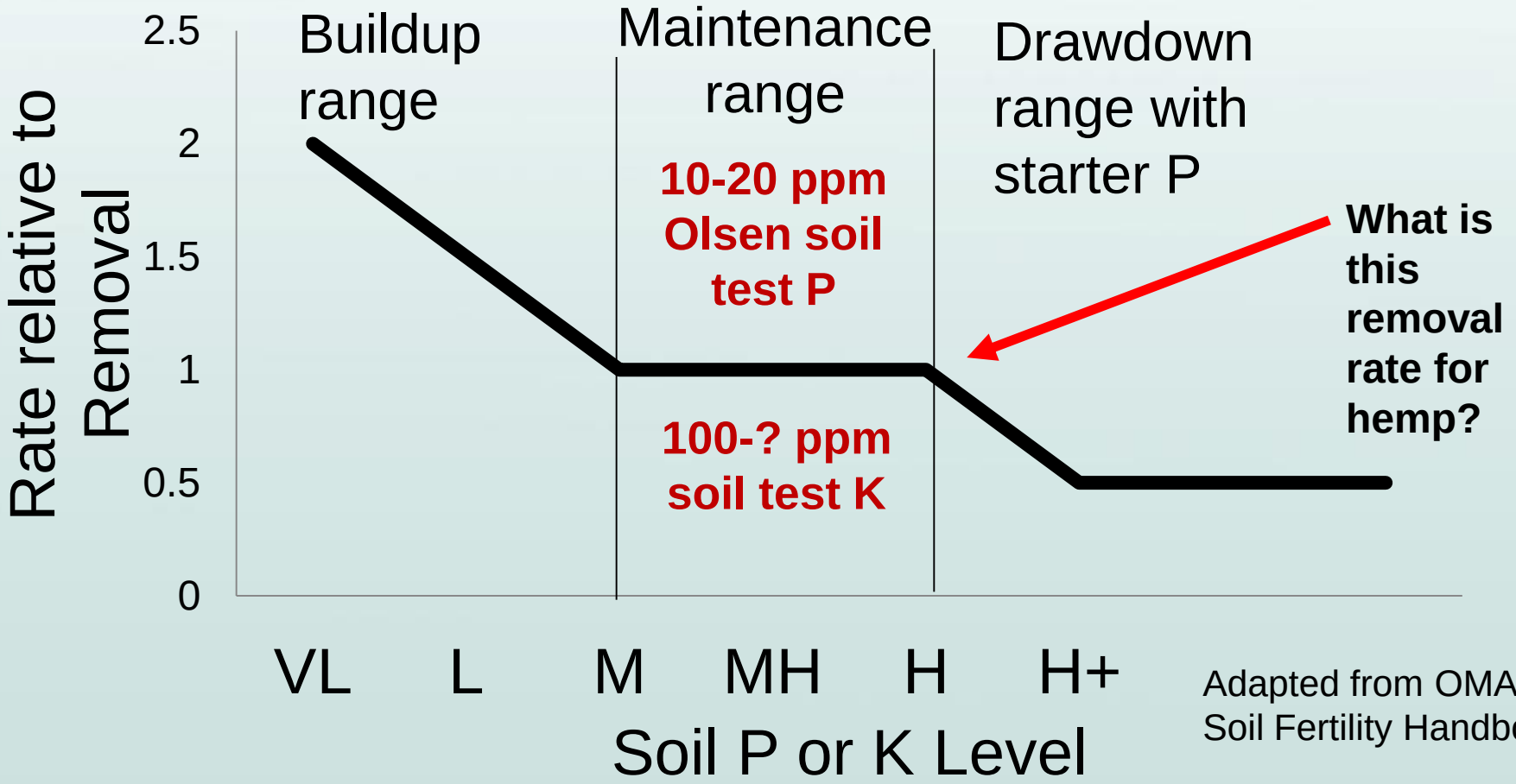
60-100 P_2O_5

60-180 K_2O

John's recent google literature review

Area	N (lb/ac)	P_2O_5 (Lb/ac)	K_2O (lb/ac)	S (lb/ac)	Similar to:
Manitoba	80-120	40	60	15	High yield wheat
Saskatchewan	90	45	60	17	High yield wheat
Alberta	Up to 120		35-80		
Ontario	100	45-70	35-80		Winter wheat
Montana					Canola
Kentucky	150				170 bu/ac corn
Indiana	100-130	45-70	35-80		Wheat or corn
Wisconsin	100-140	45 @M STP	60 @ M STK	0-15	
Pennsylvania	150	20-40 @ M STP	10 -20 @ M STK		

A fertilization concept to move soil P and K levels into an optimum range over time



Adapted from OMAF Soil Fertility Handbook

Nutrient Uptake and Partitioning by Industrial Hemp

John Heard, Keith Watson and Jeff Kostiuk, Manitoba Agriculture, Food and Rural Initiatives John.Heard@gov.mb.ca

Background

Industrial hemp is grown under license in Canada for seed and/or fibre. Total Canadian production in 2006 was 20,545 ha with 11,721 ha in Manitoba. Little local information exists on the fertility needs of the crop, and removal amounts may differ greatly whether grown for seed alone or for fibre The following study was initiated to track nutrient uptake through a growing season, to observe partitioning within the plant and to establish removal amounts.

Dual purpose hemp is combined with the cutter bar raised to remove the top portion of the plant and leaving much of the stalk. The remaining stalk is swathed and allowed to "rett" or weather on the ground to separate fibres from other stem tissue before baling (see

Method

A commercial 65 ha hemp field in northwestern Manitoba near Dauphin was selected for the study. The soil was a moderately well drained Gilbert sandy loam. The field had previously been cropped to oats and alfalfa hay.

The cultivar USO 31 was seeded on May 12, 2007 at 39 kg/ha with a zero-till air seeder in 25 cm wide rows with a 7.5 cm wide seed spread. The previous fall 150 kg K_2O/ha was broadcast followed by 67 kg N, 37 kg P_2O_5 and 11 kg S/ha in a mid-row band at seeding. Combine harvest of the entire field on September 19 averaged 1067 kg/ha of clean seed.

Plants were sampled from a 3 m row length on a 2-week schedule (see figures below) in a RCBD sampling pattern with 2 replicates. Above-ground parts were sampled, partitioned, dried, chopped and ground for nutrient analysis by ALS Labs. Flower material was considered the reproductive portion of the head and the chaff after threshing the seed. The August 9 sampling had excessive leaf loss

June 26
354 GDD
35 cm
Vegetative

July 12
546 GDD
90 cm
Vegetative

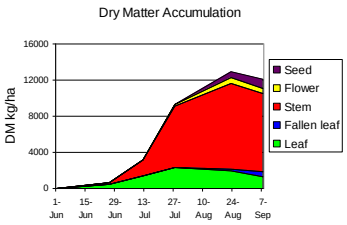
July 27
782 GDD
215 cm
Flower Initiation

August 9
971 GDD
215 cm
Pollination

August 23
1105 GDD
245 cm
Seed filling

September 7
1258 GDD
240 cm
Mature

Dry matter (DM) accumulation



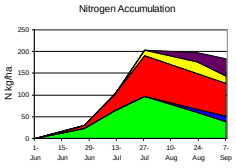
Total biomass exceeded 12000 kg/ha with a grain yield of 1042 kg/ha with a harvest index of 8.6%.

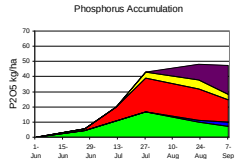
Greatest rate of DM accumulation was in late July at 410 kg/ha/day

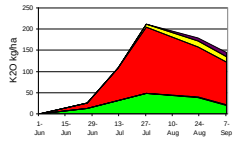
Rate of biomass accumulation slowed in August during flowering, with high temperatures and moisture stress. Some leaf senescence was observed.

Males plants (about 10% of stand) cease growth and senesce after flowering.

Primary nutrient uptake







Total nitrogen (N) uptake was 200 kg/ha with 40 kg N/ha in the grain.

•Maximum rate of N uptake was 6.7 kg N/ha/day during rapid vegetative growth in late July.

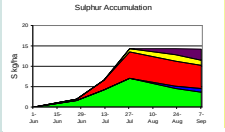
•Some 60 kg N/ha disappeared from vegetative tissue between flowering and maturity with 40 kg N/ha moving into the seed.

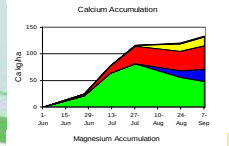
Total phosphorus (P) uptake was 47 kg P_2O_5/ha with 40% in the grain.

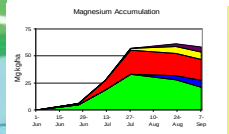
•Rate of P uptake was 1.56 kg P_2O_5/ha/day in late July and later accumulated in grain at 0.61 kg P_2O_5/ha/day.

The rate of potassium (K) uptake during vegetative growth in July was 6.0 kg K_2O/ha/day. The greatest K uptake was 211 kg K_2O/ha in late July at the start of flowering. By maturity, K content had declined by 66 kg K_2O/ha with only 10 kg K_2O/ha removed in the grain.

Secondary nutrient uptake







Total sulphur (S) uptake was 14 kg S/ha with 20% in the grain.

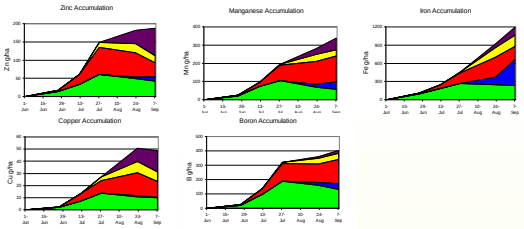
•S appeared to be translocated from leaves to the grain.

Calcium (Ca) uptake was greater than expected

•Most Ca was present in leaves (53%), stem (33%) and flower (12%) with very little accumulation in the seed.

Greatest magnesium (Mg) uptake was 58 kg Mg/ha with 8% in the grain.

Micronutrient uptake



Micronutrient uptake was small with Fe >Mn>B>Zn>Cu.

•Iron (Fe) appeared to increase through grain fill but is likely a result of soil contamination on fallen leaves

•Zn and Cu appeared to translocate from vegetative tissue and accumulate in the seed, whereas Mn, Fe and B remained in vegetative tissue.

Influence of retting on nutrient removal

For fibre harvest, the stalks are swathed and left in the fields to "rett" or for fibres to loosen. During this weathering process nutrients may be leached from the stalk into the soil. The following table shows the yield and nutrient content of hemp stalks sampled from this field. It is apparent that despite high uptake of potassium, very little is actually removed when hemp is allowed to rett in the field.

Stalk sample	Stalk Yield Kg/ha	Nitrogen	Phosphorus	Potassium	Sulphur
		Content % (kg/ha)			
September 7 Standing	8684	0.87 %N 75 kg N/ha	0.07 % P 14.8 kg P_2O_5/ha	0.97 %K 100.7 kg K_2O/ha	0.07 %S 5.6 kg S/ha
October 16 Standing 126 cm	4561	0.62 %N 28 kg N/ha	0.05 %P 5.2 kg P_2O_5/ha	0.54 %K 29.6 kg K_2O/ha	0.07 %S 3.2 kg S/ha
October 16 Retted	Assumed 4561	0.72 %N 33 kg N/ha	0.06 %P 6.2 kg P_2O_5/ha	0.11 %K 5.9 kg K_2O/ha	0.06 %S 2.7 kg S/ha

Discussion

The magnitude of nutrient uptake was similar to that observed in earlier Manitoba studies (1.) The rapid hemp growth that occurred in July caused most nutrients to be taken up at high rates. Nutrient accumulation slowed after this period for a number of possible reasons:

- Male plants comprise about 10% of the population and they cease growth and senesce after pollination.
- Several days exceeding 30°C and low soil moisture occurred in early August leading to some lower leaf senescence. Not all senescing leaves may have been captured during our sampling.
- Stalk growth generally slows during flowering but resumes during seed development.

Although the hemp crop takes up a considerable quantity of nutrients, most remain in the stalk owing to the low harvest index and a low amount is removed in grain (the exception being P). With the retting process in the field, the majority of the potassium taken up and apportioned in

References

1. Heard, J. 2001. Industrial hemp seed fertility: Summary of Manitoba studies. In Proceedings of 44th Annual Manitoba Soil Science Society Meetings. Winnipeg. 2001. pp. 180-185.

Acknowledgements

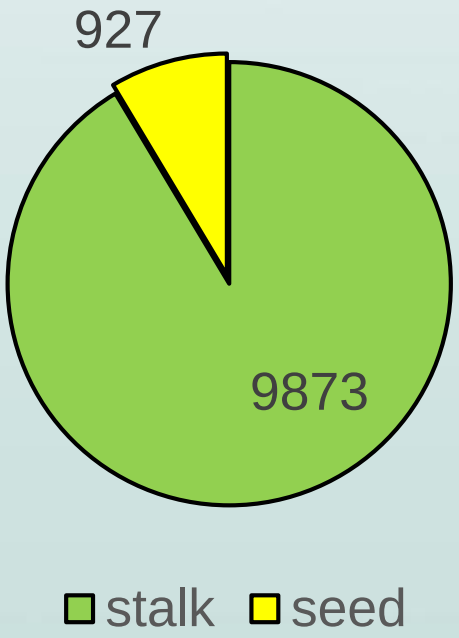
Covering New Ground Diversification Foundation
Parkland Crop
ALS Laboratory Group

2018 - CRS-1 at Arborg, Roblin and Carberry

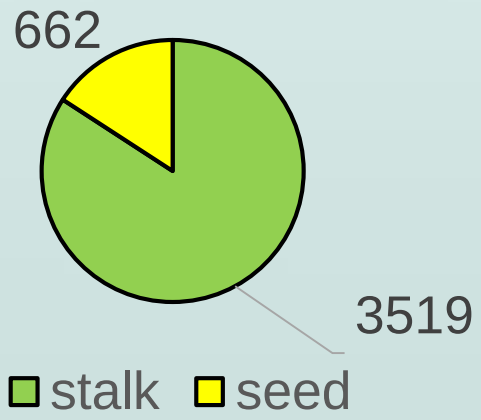
Seed analysis by Farmers Edge Labs

2 data sets – different yrs, varieties

- USO 31 in 2007 at Dauphin
- Yield lb/ac



- CRS-1 – (predominantly seed cultivar) in 2018 at Melita, Carberry and Arborg
- Seed yields 662, 921 and 809 lb/ac respectively
- samples from Melita suffered bird damage



2007 Sampling Stages

Manitoba

June 26
354 GDD
35 cm
Vegetative

July 12
546 GDD
90 cm
Vegetative

July 27
782 GDD
215 cm
Flower
Initiation

August 9
971 GDD
215 cm
Pollination

August 23
1105 GDD
245 cm
Seed filling

September 7
1258 GDD
240 cm
Mature

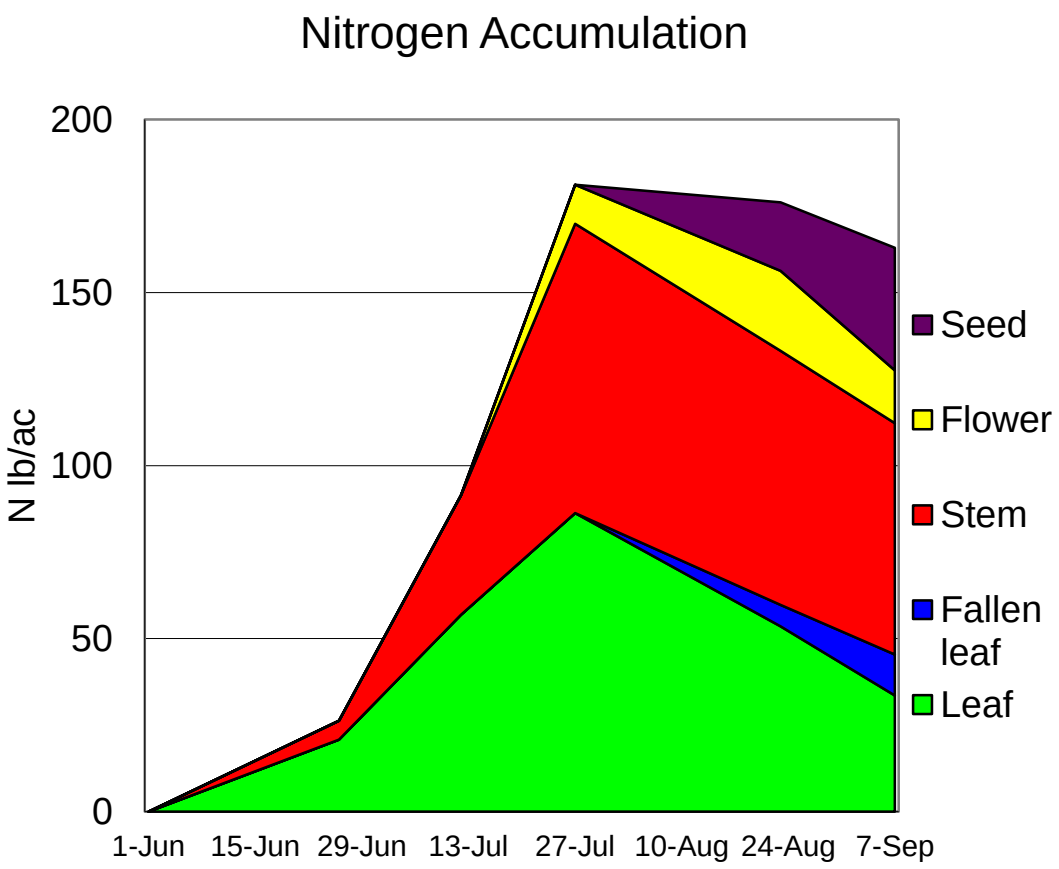
Whole Plant Nutrient Uptake at maturity (lb per acre)

Nutrient	2007 USO 31	2018 CRS-1 (1)
N	163	54
P_2O_5	41	19
K_2O	129	72
S	13	7

More value by scaling nutrient removal per unit yield:

- Seed nutrient uptake scaled according to 1000 lb seed yield
- Stalk nutrient scaled according to seed yield and stalk yield

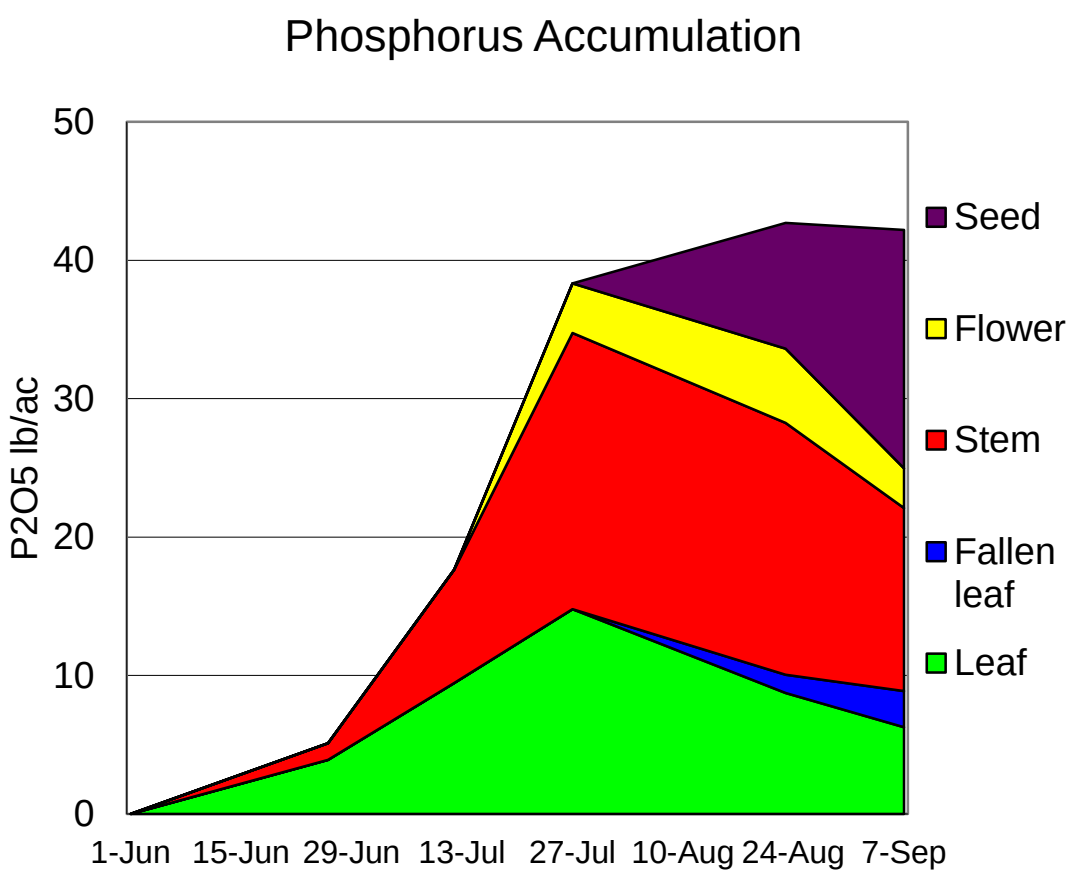
Nitrogen Uptake



		N Lb/ac	Lb/1000 lb seed (1000 lb stalk)
Seed	**2007**	**35**	**37**
	2018	31	37
Stalk	**2007**	**128**	**92 (13)**
	2018	23	35 (8)
Total	**2007**	**163**	**129**
	2018	54	72

		Change lb N/ac flower to mature
Seed	**2007**	**+14**
	2018	-7
Stalk	**2007**	**-29**
	2018	-41
Total	**2007**	**-14**
	2018	-48

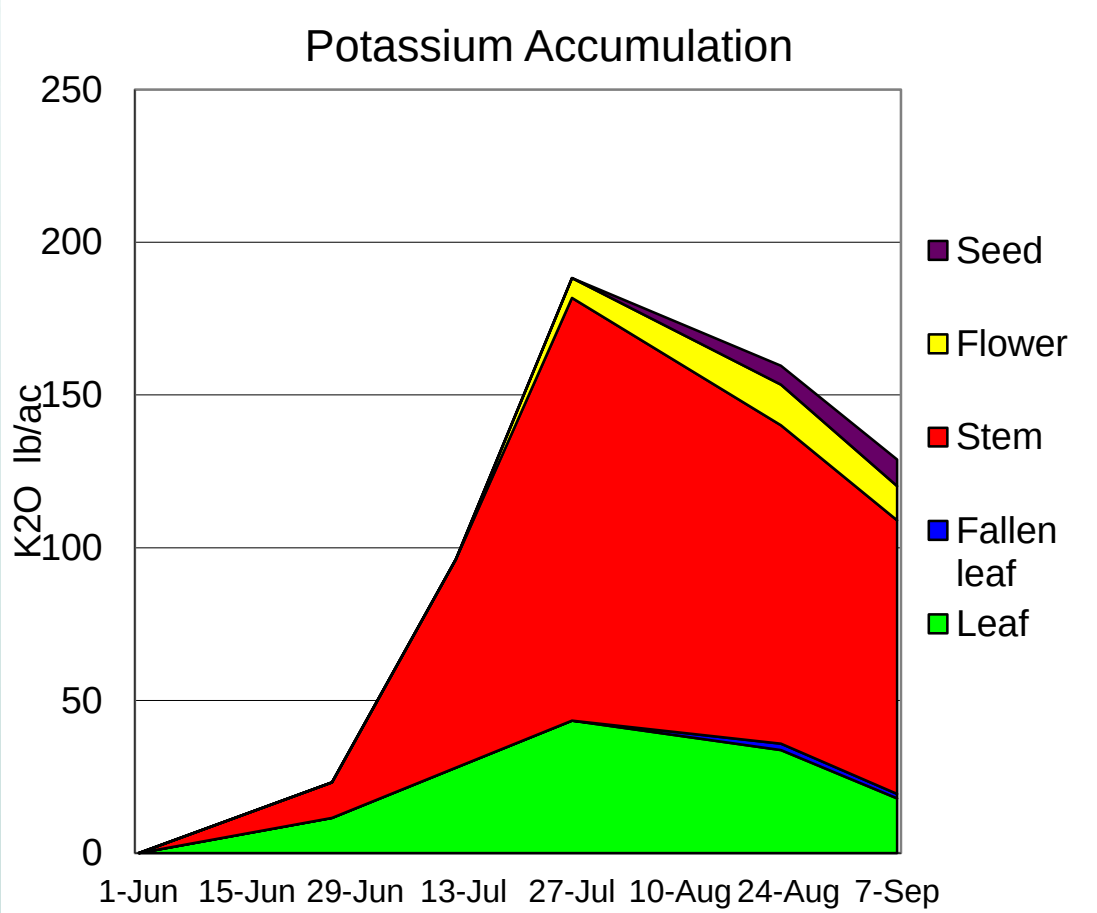
Phosphorus Uptake



		P_2O_5 Lb/ac	Lb/1000 lb seed (1000 lb stalk)
Seed	**2007**	**17**	**18.7**
	2018	14	17.3
Stalk	**2007**	**16**	**17.0 (1.6)**
	2018	5	8.1 (1.4)
Total	**2007**	41	**36**
	2018	19	**25**

		Change lb P_2O_5/ac flower to mature
Seed	**2007**	**+8**
	2018	+8
Stalk	**2007**	**-9**
	2018	-2
Total	**2007**	**-1**
	2018	+6

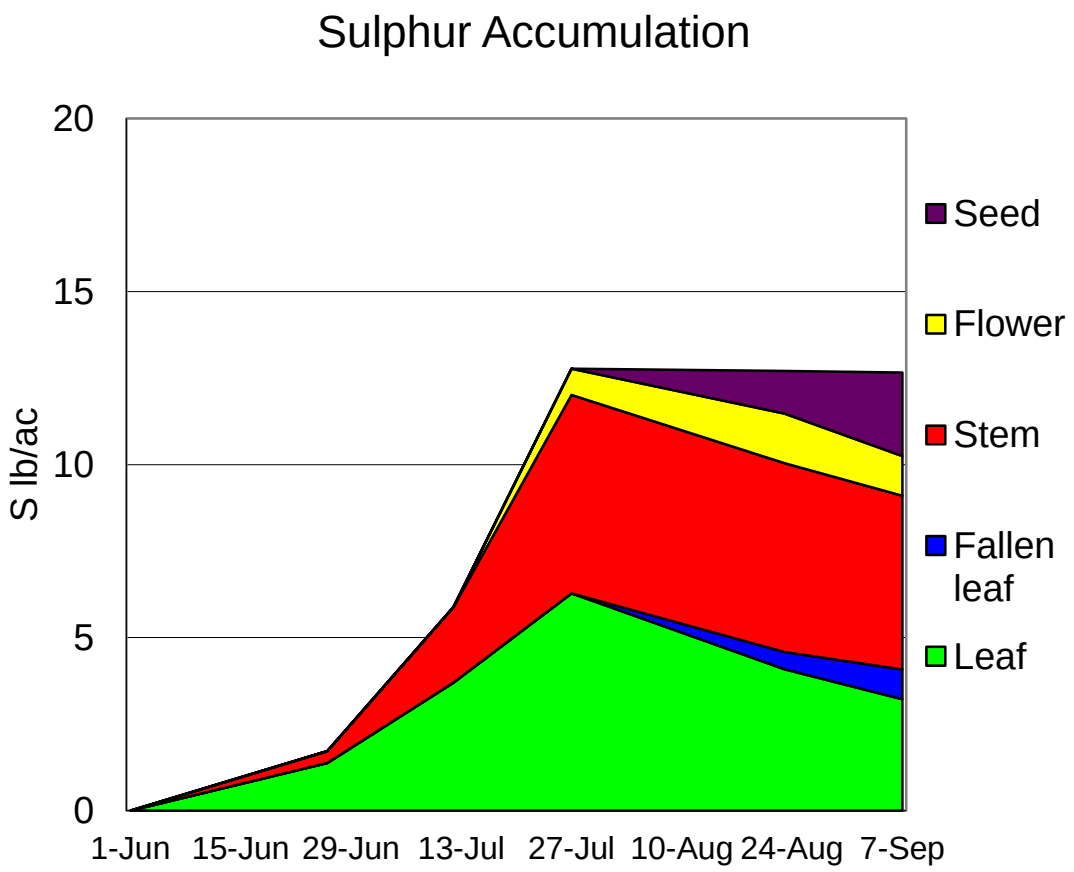
Potassium Uptake



		K_2O Lb/ac	Lb/1000 lb seed (1000 lb stalk)
Seed	**2007**	**8.7**	**9.4**
	2018	7.7	9.4
Stalk	**2007**	**120**	**124 (12.2)**
	2018	65	98 (8.5)
Total	**2007**	**129**	**133**
	2018	72	**107**

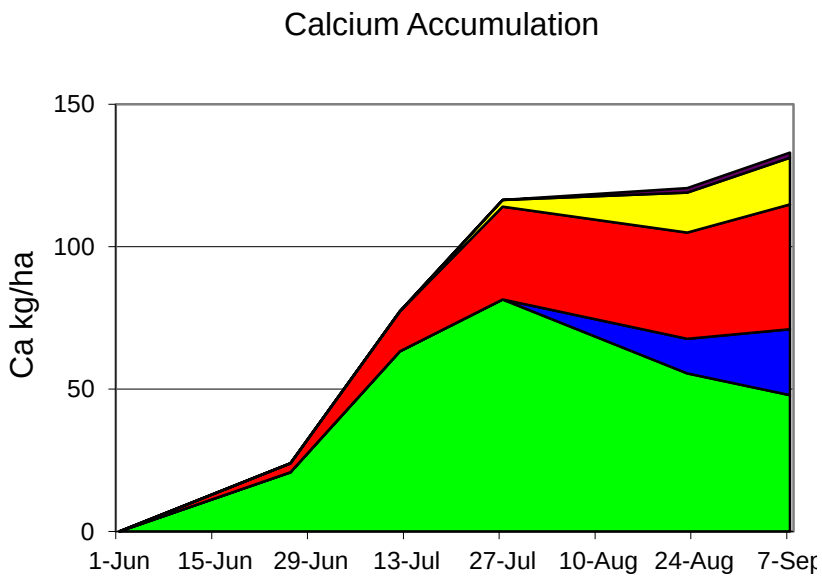
		Change lb K_2O/ac flower to mature
Seed	**2007**	**+3**
	2018	-10
Stalk	**2007**	**-34**
	2018	-22
Total	**2007**	**-31**
	2018	-32

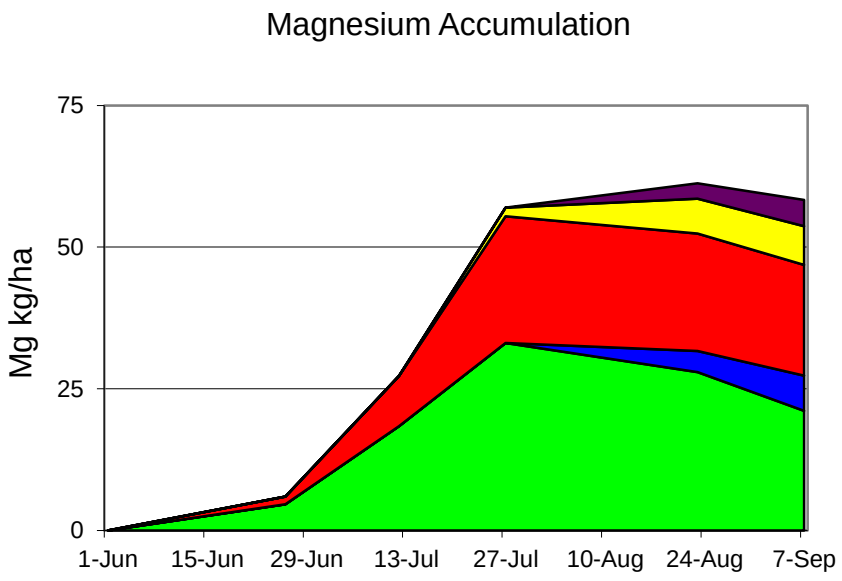
Sulphur Uptake



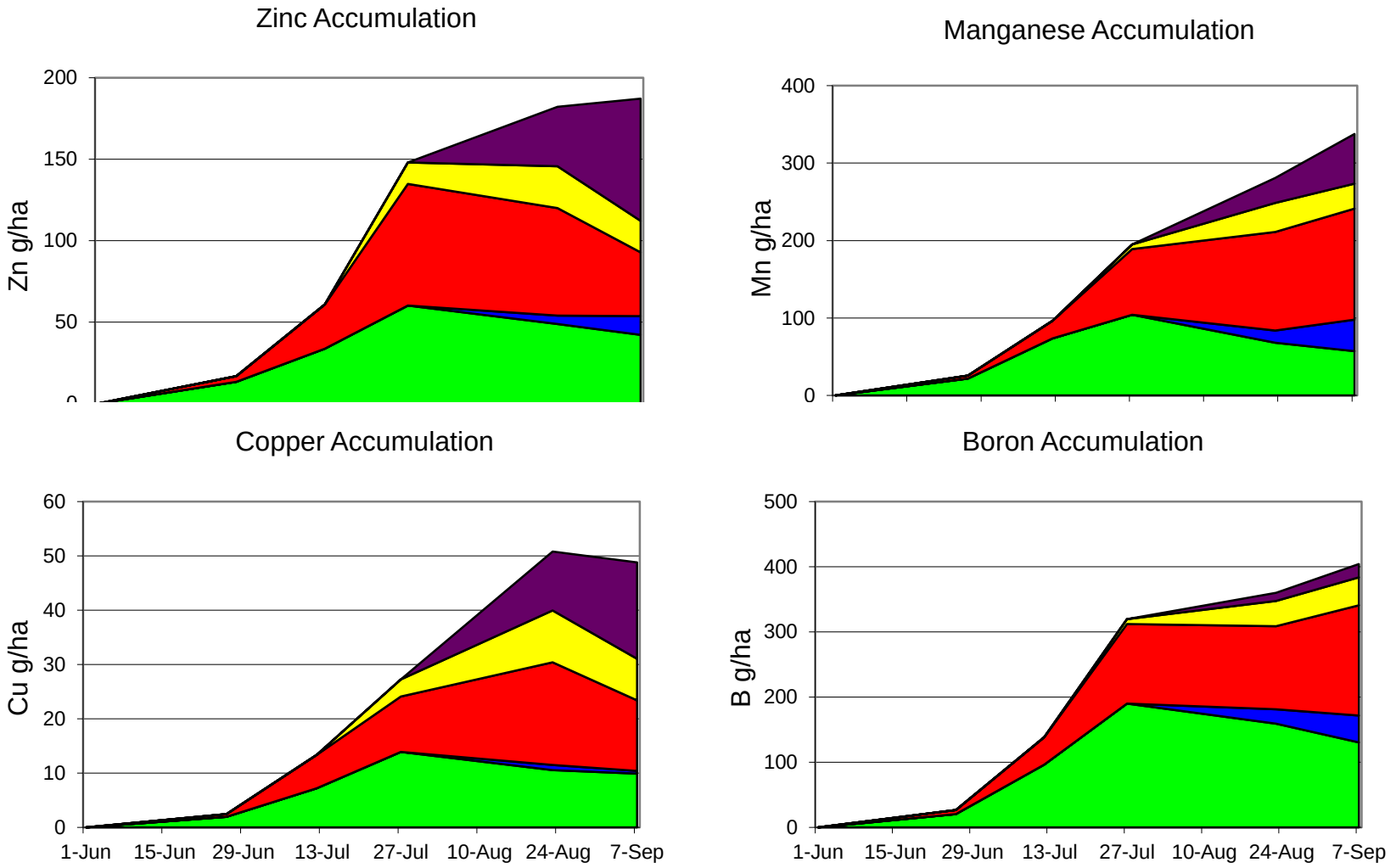
		S Lb/ac	Lb/1000 lb seed (1000 lb stalk)
Seed	**2007** 2018	**2.4** 2.4	**2.6** 2.9
Stalk	**2007** 2018	**10.2** 4.1	**7.5 (1.0)** 6.2 (1.8)
Total	**2007** 2018	**12.6** 6.5	**10** 9

Calcium and magnesium





Micronutrient Uptake

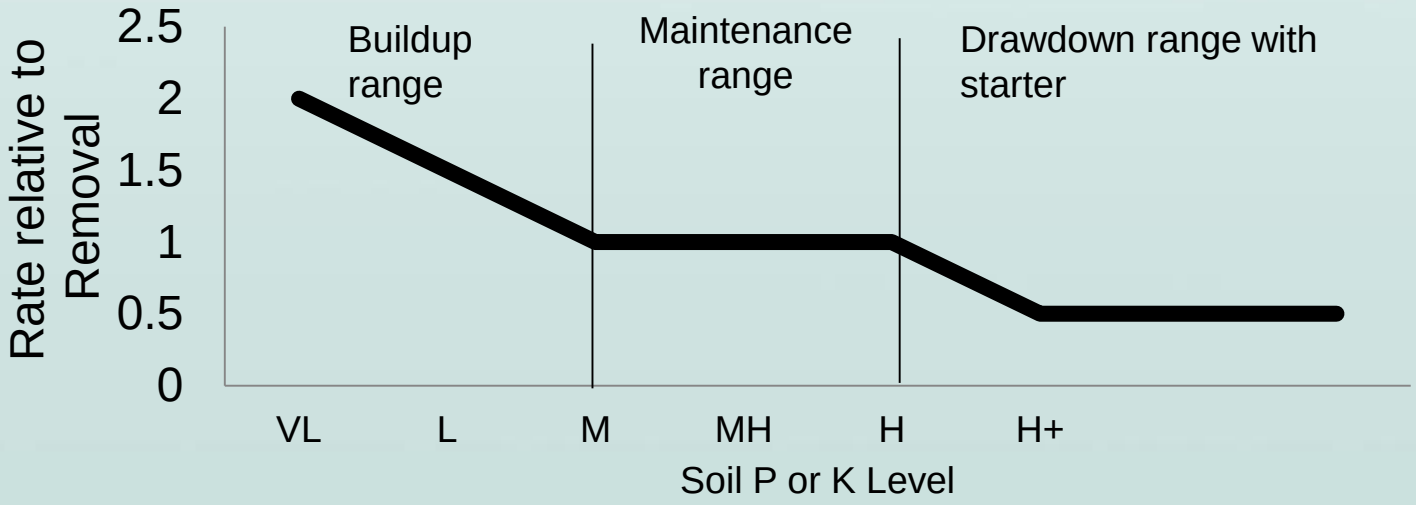


Seed Nutrient Removal (lb per 1000 seed)

Nutrient	2007 USO 31	2018 CRS-1 3 site ave & std dev	
N	36.9	37.5	1.63
P2O5	18.7	17.3	2.56
K2O	9.4	9.4	1.04
S	2.6	2.9	0.30
Ca	1.7	1.2	0.17
Mg	4.4	4.0	0.28
B	0.020	0.012	0.001
Cu	0.017	0.016	0.001
Fe	0.125	0.085	0.024
Mn	0.062	0.12	0.015
Zn	0.072	0.065	0.012

If basing P and K fertilization guidelines on removal in seed:

Realistic Yield	Lb P_2O_5 /ac	Lb K_2O/ac
1000 lb /ac	17 P_2O_5	9 K_2O
1500 lb/ac	25 P_2O_5	14 K_2O
2000 lb/ac	34 P_2O_5	18 K_2O




Fibre Harvest

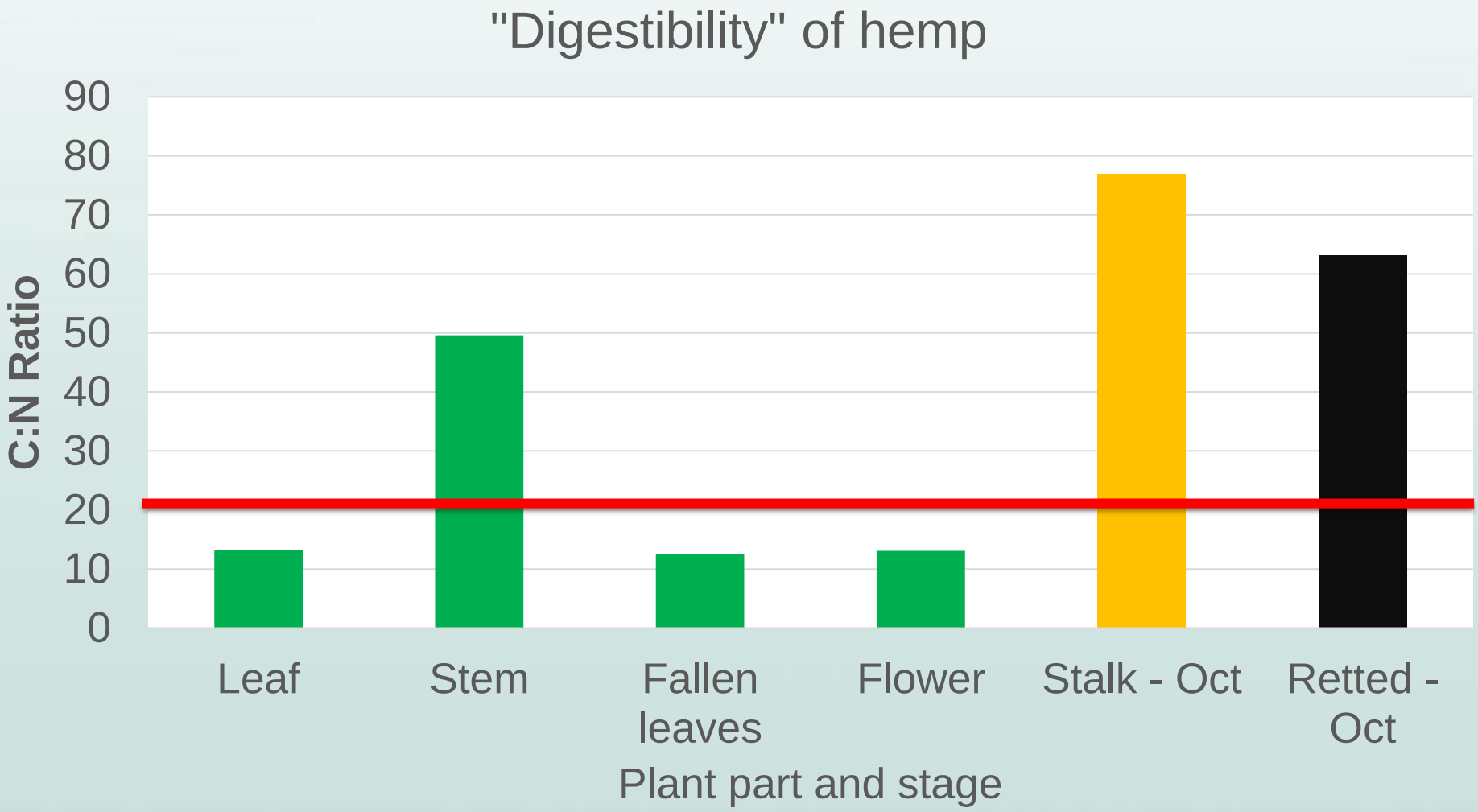
Stalks left in the field

- For fibre harvest, the stalks are swathed and left in the fields to "rett" or for fibres to loosen. During this weathering process nutrients may be leached from the stalk into the soil. The following table shows the yield and nutrient content of hemp stalks sampled from this field. It is apparent that despite high uptake of potassium, very little is actually removed when hemp is allowed to rett in the field.

	% N	% P	% K	% S
Sept 7 standing	0.87	0.07	**0.97**	0.07
Oct 7 standing	0.62	0.05	**0.54**	0.07
Oct 7 retted	0.72	0.06	**0.11**	0.06

Watch for the “canola swath syndrome” on low K soils

Dealing with the hemp residue 1)C:N Ratio and 2) Fiber



Summary Comments

- Yields (esp stalk) varied between the years/cultivar
- When nutrient uptake and removal was scaled according to seed yield, values were very similar.
- Interim P & K fertility guidelines on removals?
- Considerable biomass and nutrients can be “lost” between flowering and maturity (senescence, male plant death, birds)
- Much of K can be leached from remaining stalks if left in the field

Credits

- MB Crop Diversification sites:
- WADO – Melita
- CMCDC – Carberry
- PCDF – Roblin
- PESAI – Arborg
- Hemp Genetics International (HGI) for cost of analysis