Nutrient Uptake and Partitioning by Industrial Hemp

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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 photographs below).

Method

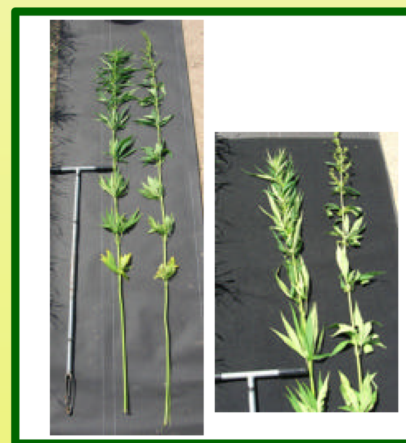
A commercial 65 ha hemp field in northwestern Manitoba near Dauphin was selected for the study. The soil was a moderately well drained Gilbert sandy loam. The field had previously been cropped to oats and alfalfa hay.

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.

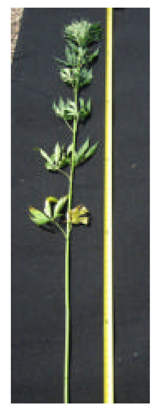
Plants were sampled from a 3 m row length on a 2-week schedule (see figures below) in a RCBD sampling pattern with 2 replicates. Above-ground parts were sampled, partitioned, dried, chopped and ground for nutrient analysis by ALS Labs. Flower material was considered the reproductive portion of the head and the chaff after threshing the seed. The August 9 sampling had excessive leaf loss in handling and data is not shown here. Fallen leaves were captured for later sampling dates.

June 26
354 GDD
35 cm
Vegetative

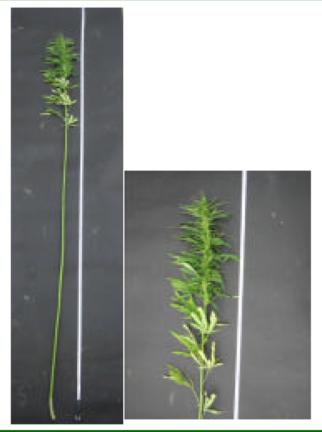
July 12
546 GDD
90 cm
Vegetative



July 27
782 GDD
215 cm
Flower
Initiation



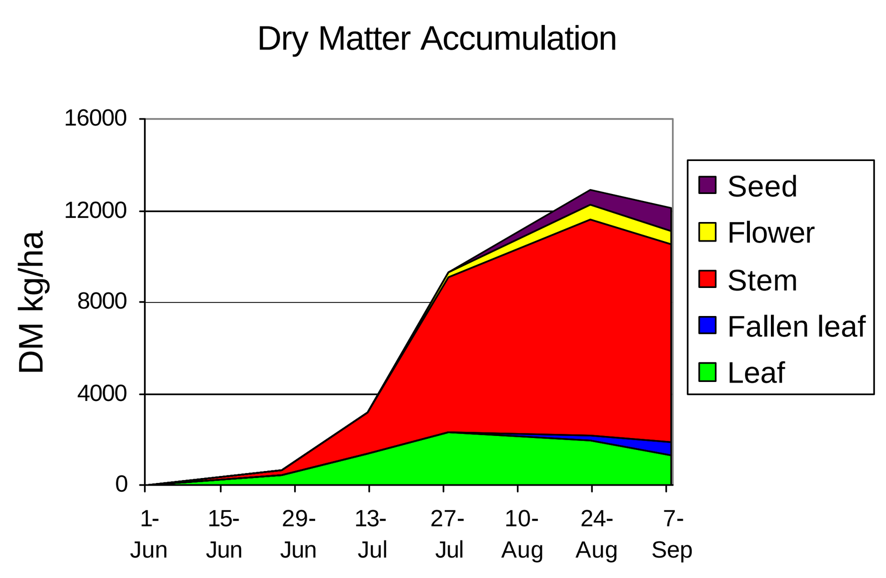
August 9
971 GDD
215 cm
Pollination



August 23
1105 GDD
245 cm
Seed filling

September 7
1258 GDD
240 cm
Mature

Dry matter (DM) accumulation



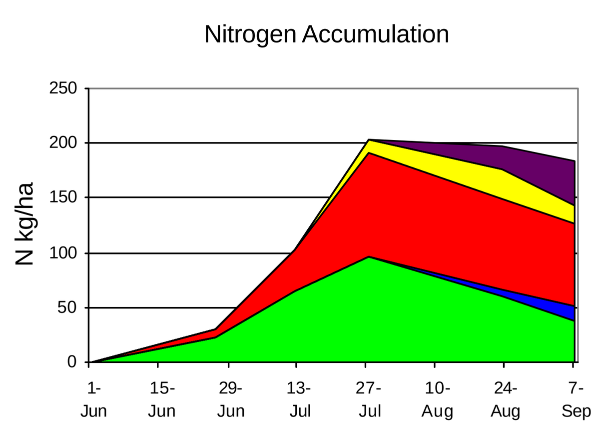
Total biomass exceeded 12000 kg/ha with a grain yield of 1042 kg/ha with a harvest index of 8.6%.

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.

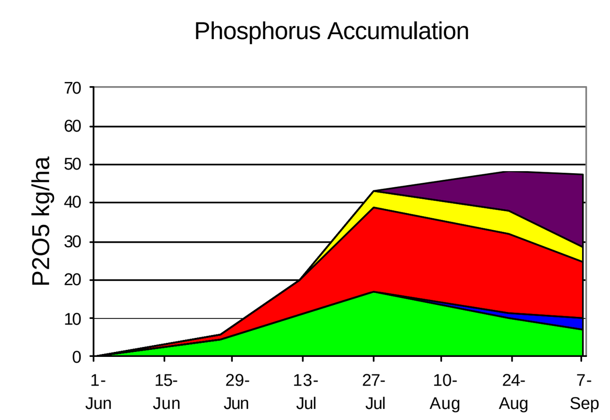
Primary nutrient uptake



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

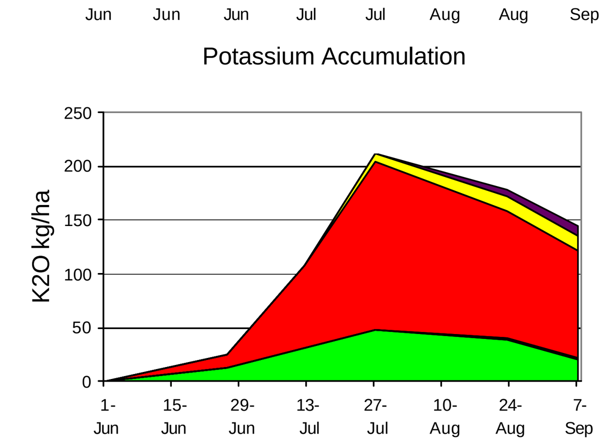
•Maximum rate of N uptake was 6.7 kg N/ha/day during rapid vegetative growth in late July.

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



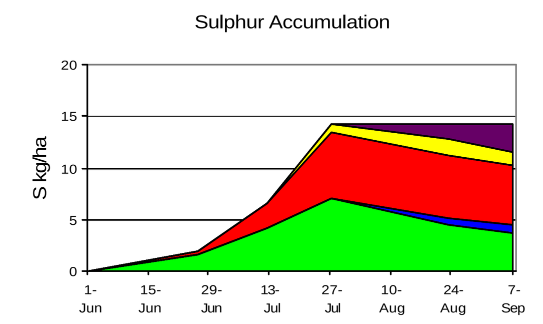
Total phosphorus (P) uptake was 47 kg P_2O_5/ha with 40% in the grain.

•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.



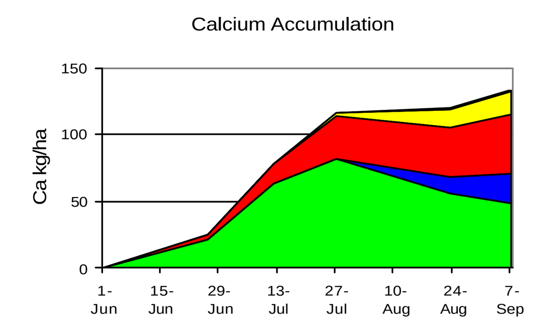
The rate of potassium (K) uptake during vegetative growth in July was 6.0 kg K_2O/ha/day. The greatest K uptake was 211 kg K_2O/ha in late July at the start of flowering. By maturity, K content had declined by 66 kg K_2O/ha with only 10 kg K_2O/ha removed in the grain.

Secondary nutrient uptake



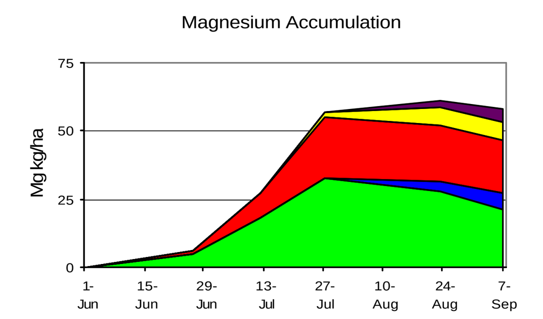
Total sulphur (S) uptake was 14 kg S/ha with 20% in the grain.

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



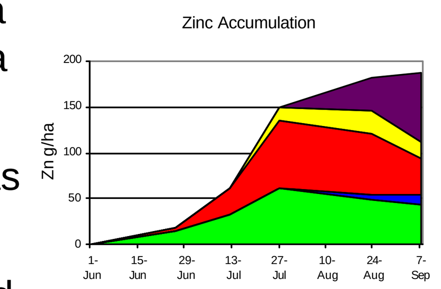
Calcium (Ca) uptake was greater than expected

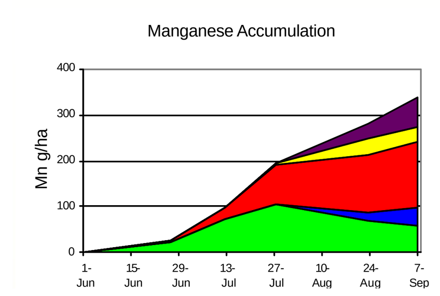
•Most Ca was present in leaves (53%), stem (33%) and flower (12%) with very little accumulation in the seed.

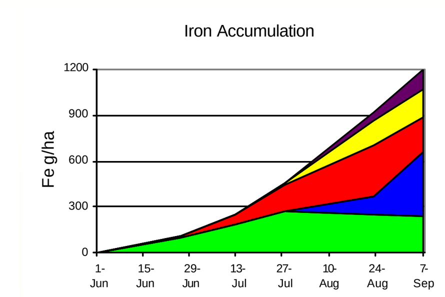


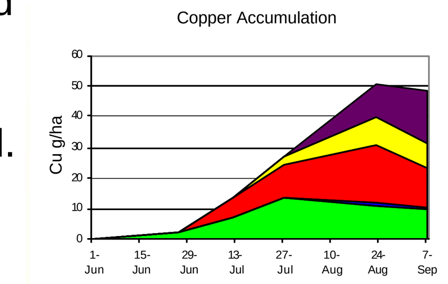
Greatest magnesium (Mg) uptake was 58 kg Mg/ha with 8% in the grain.

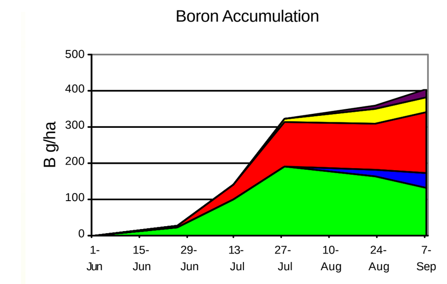
Micronutrient uptake











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 30ºC 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 the stalk appears be leached out. This does have some agronomic implication as potassium is concentrated under swaths.

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
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