Nutrient Uptake and Partitioning by Soybeans in Manitoba

John Heard, Soils and Crops Branch, Manitoba Agriculture, Food and Rural Initiatives
jheard@gov.mb.ca

Abstract
Soybean plants were analysed for nutrient uptake and removal through the growing season. The 45 bu/ac crop took up some 200 lb N/ac and removed 88% in the grain, leaving little residual N for following crops in the surprisingly high C/N ratio leaf, stem and pod material. Typical rate of N, P_2O_5 and K_2O uptake during the growing season were 4, 1 and 4 lb/ac/day, respectively. Much K was lost from senescing leaves. Nutrient translocation from vegetative parts to seed was observed for N, P, K, S, Zn and Cu.

Introduction

Soybeans are increasing in acreage in Manitoba, and the nutritional requirements are different than most other prairie crops in respect to N and K uptake and removal. Many growers have felt that this "nitrogen factory" would supply following crops with considerable nitrogen, yet recent studies have documented little contribution. Past studies have illustrated soybean nutrient uptake and removal of macronutrients (Hanway and Weber, 1971) and industry standards for crop uptake and removal are available, yet validation under our modest yield environment would be helpful for use in future nutrient management plans.

Materials and Methods

A field of commercial soybeans was selected near Carman in the south-central area of Manitoba. The soil was moderately well-drained Reinfeld clay loam soil. The full season variety, OAC Prudence, was seeded in 8" rows on May 22, 2005. Seed was inoculated and fertilizer applied to supply 40 lb N/ac, 20 lb P_2O_5/ac and 20 lb K_2O /ac. Weeds were controlled with Pursuit Ultra herbicide.

To determine nutrient uptake and accumulation, whole plant samples were taken at selected growth stages during the season (Table 1). Sampling was according to a randomized complete block design with 3 replicates.

Table 1. Soybean sampling stages and cumulative corn heat units (CHU) and rainfall.

Sampling Date	Growth stage and description	CHUs		Precipitation mm	
		2005	Normal	2005	Normal
July 6	V4 – 4th trifoliate leaf	851	891	154	117
July 15	R1 – 1st flower	1076	1101	172	141
July 25	R3 – beginning pod formation	1296	1335	207	161
August 5	R4 – full pod, ¾" long pod	1537	1583	215	185
August 17	R6 – full seed size	1774	1842	225	212
September 28	R8 – full maturity	2453	2479	268	289

At sampling the plants were cut at ground level, separated into plant portions (leaf, stem, pods and seed), dried, ground and submitted for full nutrient analysis by AgVise Laboratories, Northwood, ND. At the final sampling date, most leaves had dropped and were collected from the soil surface and rinsed of soil before drying.

Phosphorus (P) and potassium (K) levels are converted to the oxide forms (P_2O_5 and K_2O) to equate to "fertilizer nutrient" values. The daily rate of dry matter and nutrient accumulation was determined based on the interval between samplings. At the final harvest, carbon content was determined to determine the

C/N ratio for the plant parts. Soil sampling was conducted prior to seeding and following harvest to track nutrient changes.

Results and Discussion

Corn Heat Unit (CHU) accumulation and rainfall was very similar to that normally expected (Table 1). The greatest crop stress was due to heavy rainfall in mid July. Soybean yield was slightly higher than normal for this northern growing area, with combine harvested yield from the entire field averaging 32 bu/ac.

Total dry matter accumulation at harvest was 5959 lb/ac (Figure 1). The grain portion was 2729 lb/ac or 45.5 bu/ac with a harvest index of 46%. The remaining biomass at maturity consisted equally of leaves, stem and pods. Rate of dry matter accumulation was greatest for leaves and stems during mid July between R1 and R3 stages when the plant accumulated 129 lb/ac/day. Leaf biomass was greatest at R4 and declined during seed filling. Very little apportioning of dry matter from the stem and pod to the seed was observed. During seed filling (R6 to R8), the seed accumulated dry matter at 57 lb or almost 1bu/ac/day.

Total aerial nitrogen (N) accumulation was 199 lb/ac, with 88% or 176 lb/ac in the grain (Figure 2). Peak accumulation in leaves and stem was 71 and 33 lb N/ac, respectively, at the R4 stage. Between R1 and R4, the plant accumulated nitrogen at 4.3 lb N/ac/day. During seed filling, the seed accumulated N at 3.7 lb N/ac/day, largely translocated from vegetative tissue.

Previous Manitoba studies have shown little N benefit of soybeans to following cereal crops (Przednowek et al, 2004) and for this 45.5 bu/ac yield potential a N credit of only 5 lb N/ac is offered (www.umanitoba.ca/outreach/fewerchemicals/research/nbenefit.html). Observations from this study tend to support this very modest contribution. At harvest only 23 lb N/ac remained in leaf, stem and pod tissue being returned to the field and the C/N ratio of plant parts are as follows: 37:1 for leaf, 112:1 for stem, 86:1 for pod and 8:1 for seed. The soil nitrate-N content in the 0-24" depth decreased from 37 lb N/ac in May to 27 lb N/ac following harvest.

Total aerial phosphorus (P) accumulation was 62 lb P_2O_5/ac, with 86% or 53 lb P_2O_5/ac in the grain (Figure 2). At maturity, P was allocated as follows: 8% in leaves, 4% in stem and 2% in pods. Between V4 and R6, the plant P uptake rate was 0.96 lb P_2O_5/ac/day. Phosphorus is a mobile nutrient in the plant and a general decline in leaf and stem P content occurred during seed filling (R6 to R8) and the seed accumulated P at a rate of 1.1 lb P_2O_5/ac/day. Some 1.15 lb P_2O_5 was removed in each bu of seed produced.

Greatest aerial potassium (K) accumulation was 202 lb K_2O/ac at the R6 stage (Figure 2) with 50% in the leaves, 18% in the stem, 26% in pods and 7% in developing seed. By harvest on September 28 (R8 stage) a portion of the K had been mobilized to the seed but a greater portion was lost entirely mostly from senescing leaf tissue, presumably through leaching of soluble K. At harvest only 115 lb K_2O/ac remained. Between V4 and R6, the soybean plant accumulated K at a rate exceeding 4 lb K_2O/ac/day. Some 1.2 lb K_2O was removed in each bu of seed produced.

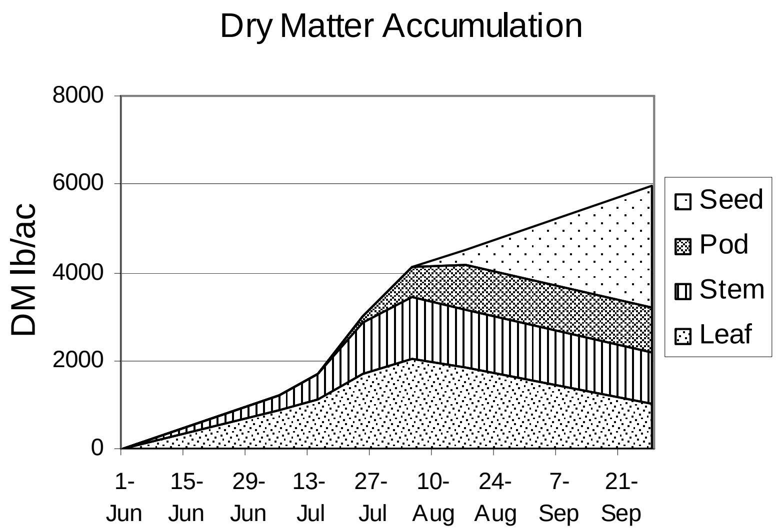
Sulphur (S) uptake by the plant was only 13 lb S/ac, with 9 lb S/ac or 72% in grain, 1.8 lb S/ac in leaves, 0.9 lb S/ac in stem and 0.7 lb S/ac in pods (Figure 2). Much of the S from leaf tissue appears to be translocated to seed. Calcium (Ca) uptake (113 lb Ca/ac) was much greater than expected, but very little if any was translocated to the seed. Greatest magnesium uptake was 38 lb Mg/ac. At harvest Mg was evenly proportioned among the leaf, stem, pod and seed.

Total accumulation of micronutrients was small; 0.18 lb Zn/ac, 0.46 lb Mn/ac, 1.36 lb Fe/ac, 0.05 lb Cu/ac and 0.25 lb B/ac (Figure 3). Iron (Fe) appeared to increase in uptake during seed fill, however inadvertent soil contamination on fallen leaves probably caused this increase. Zinc and perhaps copper appeared to be show some translocation from leaf tissue to seed. Manganese, Fe and B tended to remain in vegetative tissue.

References

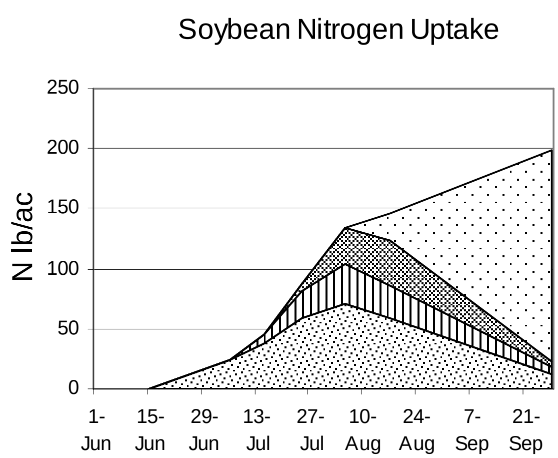
Hanway, J.J. and C.R. Weber. 1971. Accumulation of N, P, K by Soybean (*Glycine max* (L.) Merrill) Plants. Agron. J. 63:406-408.

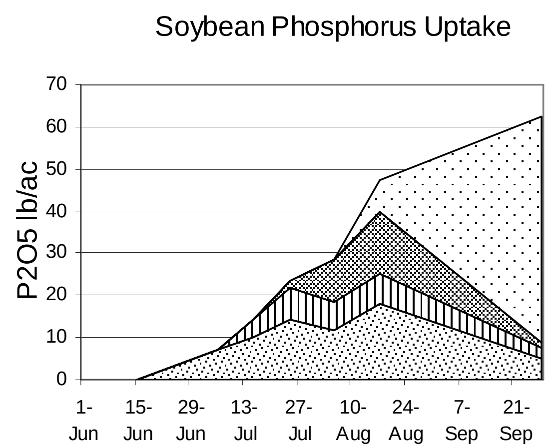
Przednowek, D.W.A., M.H. Entz, B. Irvine, D.N. Flaten and J.R. Thiessen Martens.2004. Rotational yield and apparent N benefits of grain legumes in southern Manitoba. Can. J. Plant Sci. 84:1093-1096.

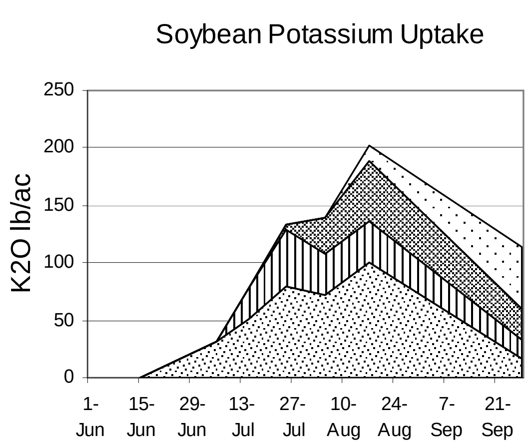


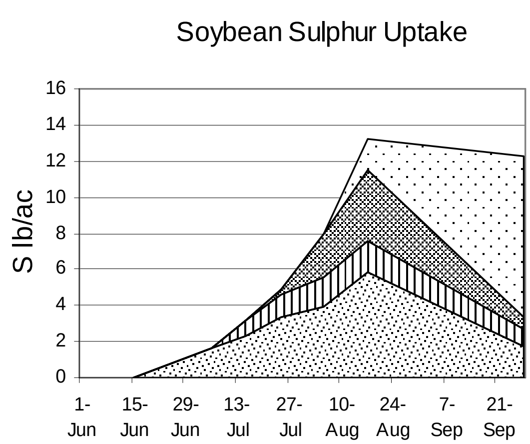
Growth Stage V4 R1 R3 R4 R6 R8

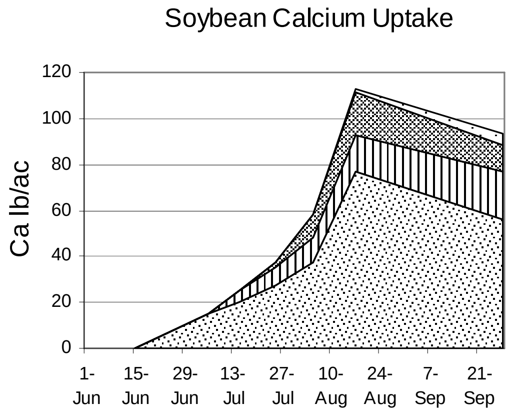
Figure 1. Aerial dry matter accumulation of soybean.











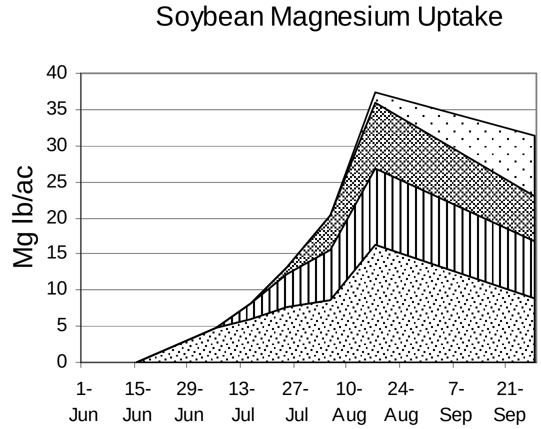
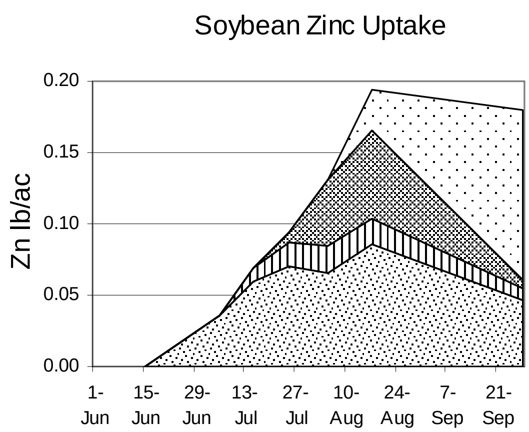
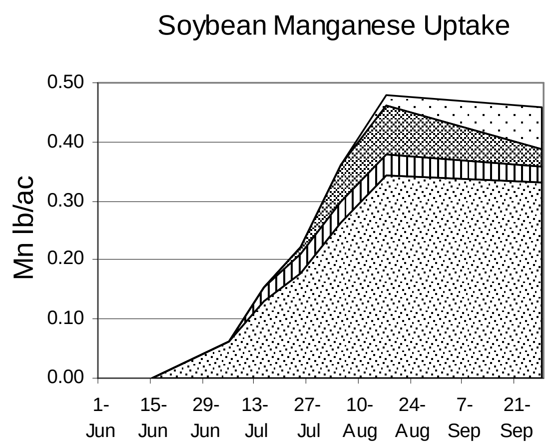
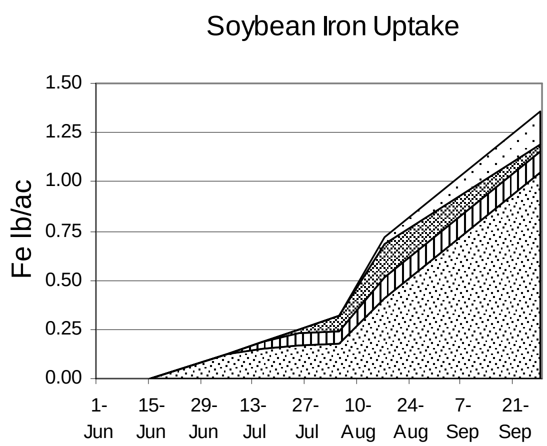
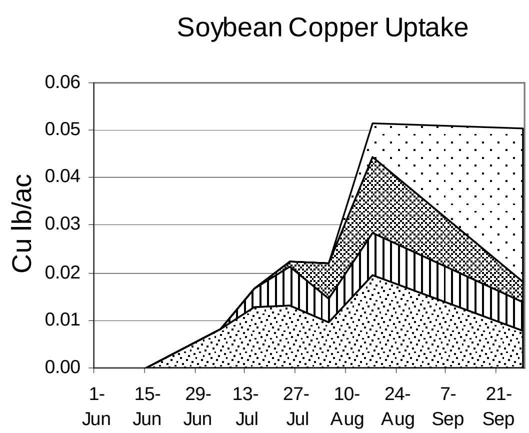


Figure 2. Nutrient accumulation by soybeans.









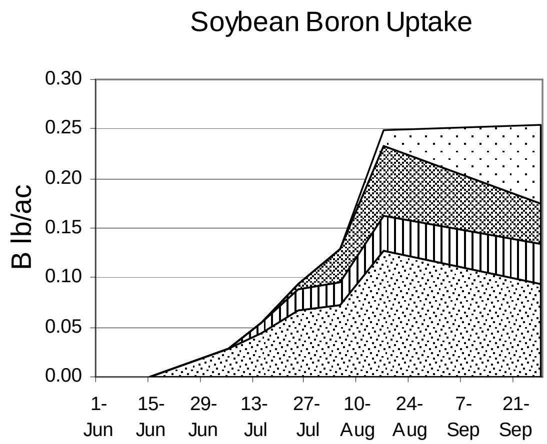


Figure 3. Micronutrient accumulation by soybeans.