Biomass Accumulation and Nutrient Uptake of Pulses at Different Growth Stages in the Parkland Region of Saskatchewan

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Abstract

Field experiments was conducted with pea (cv. Carnival and Swing), lentil (cv. Laird and CDC Milstone) and bean (cv. CDC Camino) in 1998 and 1999 at Melfort, Saskatchewan, Canada, to determine biomass and nutrient accumulation in pulses at different growth stage and their relationship to seed yield. Pulse crops followed a similar pattern in dry matter and nutrient accumulation, which increased at early growth stages, reached maximum and then decreased at late growth stages. Pulse crops usually reached their maximum biomass at medium pod forming to early seed filling stages (75-82 days after emergence). Maximum biomass accumulation rate was 175-215 kg $ha^{-1}d^{-1}$ for pea, 109-140 kg $ha^{-1}d^{-1}$ for lentil and 53 kg $ha^{-1}d^{-1}$ for bean. Maximum uptake of nutrients usually occurred at flowering to seed filling stages (59-85 days after emergence). Maximum accumulation rate of N, P, K and S, respectively, was 4.6-4.9, 0.4-0.5, 5.0-5.3 and 0.3 kg $ha^{-1}d^{-1}$ for pea, 2.4-3.8, 0.2-0.3, 2.0-3.4 and 0.2 kg $ha^{-1}d^{-1}$ for lentil and 1.1, 0.1, 1.5 and 0.1 kg $ha^{-1}d^{-1}$ for bean. Both seed yield and nutrient uptake in seed were lower in 1999 than in 1998, due to differences in weather conditions in the growing seasons in the two years. In summary, maximum nutrient accumulation rate occurred earlier than maximum biomass accumulation rate, and maximum nutrient uptake was earlier than maximum biomass. This indicates that in order to get high seed yields, there should be sufficient supply of nutrients to plants to ensure higher nutrient uptake rate at side shooting to bud forming stage, and then a greater biomass accumulation rate at early to late bud forming stage. This further suggests that adequate supply of nutrients from soil/fertilizers at early growth stages is of great importance for high-yield crop production systems.

Background

In field crops, seed yields are usually related to biomass production, or the harvest index. An understanding of crop growth and the relationship between seed yield and biomass can assist in attaining yield improvements through better agronomic practices. The increased focus on optimizing yield response to nutrient inputs and the need to ensure balanced nutrition has increased demand for information on biomass accumulation, nutrient concentration and nutrient sufficiency levels of crops. For whole and seasonal mineral nutrients requirements of crops, fertilizer scheduling and synchronizing nutrient supply with nutrient demand of the crops, it is essential to determine the exact amount of nutrient uptake over the growing season. The objective of

this study was to quantify the seasonal biomass accumulation and nutrient uptake pattern of pulse crops under conditions of optimal nutrition.

Materials and Methods

Field experiments were conducted in 1998 and 1999 on a Black Chernozemic soil. The precipitation in the growing season (from seeding to harvesting) was 150.2 mm in 1998 and 208.0 mm in 1999. Treatments included crops of field pea (cv. Carnival in 1998, Swing in 1999), lentil (cv. Laird in 1998, CDC Milstone in 1999) and pinto bean (cv. CDC Camino in 1999) arranged in a randomized complete block design in 4 replications. Test area was tilled prior to seeding to incorporate herbicides (Edge), and then was banded with a blend of N, P, K and S fertilizers to meet all nutrient deficiencies at a rate 25% higher than maximum recommended rates for all nutrients. All crops were seeded with a hoe type air drill on May 11, 1998 and May 25, 1999. Crop biomass samples were collected beginning at 3 weeks post-emergence, and continuing every 1 week until full maturity (7 samplings in 1998 and 8 samplings in 1999). At each sampling, the crop growth stage was estimated using growth staging scales of Tottman (1977). The plant samples were ground for laboratory analysis of total N, P, K, S and B. Data were plotted to illustrate the progressive accumulation of crop biomass and nutrients, and decline in nutrient concentration.

Results

Table 1 and Figure 1

Biomass accumulation, nutrient concentration and nutrient uptake varied with crop, cultivar and year. Pulse crops usually reached their maximum biomass at medium pod forming to early seed filling growth stages (75-82 days after emergence), with maximum biomass accumulation rate of 175-215 kg ha^{-1} d^{-1} for pea, 109-140 kg ha^{-1} d^{-1} for lentil, and only 53 kg ha^{-1} d^{-1} for bean.

Figures 2, 3, 4 and 5

Maximum uptake of nutrients usually occurred at flowering to seed filling growth stages (59-85 days after emergence). Maximum accumulation rate for N, P, K and S, respectively, was 4.6-4.9, 0.4-0.5, 5.0-5.3 and 0.3 kg ha^{-1} d^{-1} for pea, 2.4-3.8, 0.2-0.3, 2.0-3.4 and 0.2 kg ha^{-1} d^{-1} for lentil, and 1.1, 0.1, 1.5 and 0.1 kg ha^{-1} d^{-1} for bean.

Maximum nutrient accumulation rate occurred earlier than maximum biomass accumulation rate, and maximum nutrient uptake occurred earlier than maximum biomass. This indicates that in order to get high seed yields, soil has to be able supply sufficient amount of nutrients to ensure that plants have higher nutrient uptake rate at side shooting to early bud forming stage. This also suggests that sufficient supply of nutrients at early growth stages is of great importance for high yield.

Table 1. Days to achieve maximum biomass, biomass at harvest, grain yield and harvest index of cereal crops in the field experiments at Melfort, Saskatchewan in 1998 and 1999

Year	Crop	Cultivar	Days for maximum biomass	Maximum biomass (kg ha^{-1})	Biomass at harvest (kg ha^{-1})	Seed yields (kg ha^{-1})	Harvest indexes
1998	Pea	Carneval	75	8116	7233	3624	50.1
	Lentil	Laird	107	6676	6262	2799	44.7
1999	Pea	Swing CDC	80	7108	7077	2110	29.8
	Lentil	Milestone	82	5916	3768	429	11.4
	Bean	CDC Camino	82	2437	1692	300	17.7

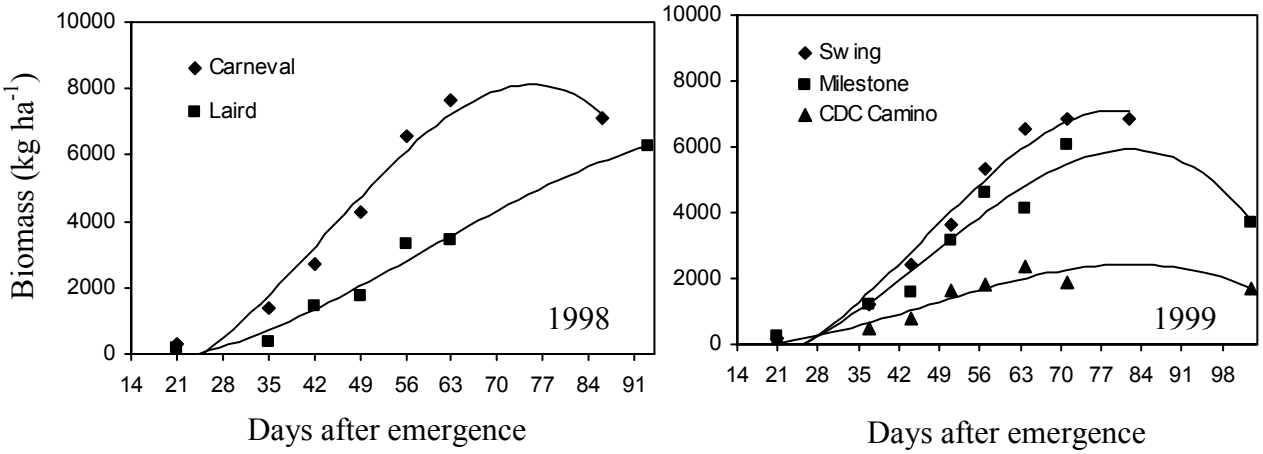

Figure 1. Changes of biomass (kg DM ha^{-1}) with days after emergence in the field experiments at Melfort, Saskatchewan.

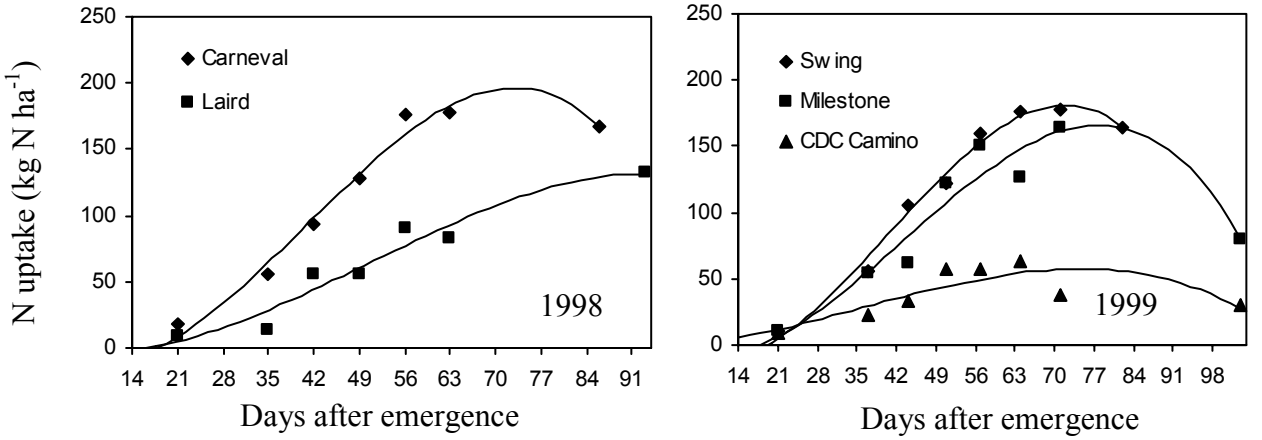

Figure 2. Changes of N uptake (kg N ha^{-1}) with days after emergence in the field experiments at Melfort, Saskatchewan.