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

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Abstract

Field experiments were conducted with canola (*Brassica napus and B. rapa*, cv. Quantum and Tobin), mustard (cv. AC Vulcan) and flax (cv. Norlin) in 1998 and 1999 at Melfort, Saskatchewan, Canada, to determine biomass and nutrient accumulation in oilseeds at different growth stages and their relationship to seed yield. In general, all oilseed crops followed a similar pattern in biomass accumulation and nutrient uptake, which increased at early growth stages, reached maximum and then decreased at late growth stages. Oilseed crops usually reached their maximum biomass at medium to end of pod forming growth stages (74-80 days after emergence), although Quest canola cultivar had a several day delay at early ripening stage (84 days after emergence) in 1998. Maximum biomass accumulation rate was 146-190 kg $ha^{-1}d^{-1}$ for canola, 158-182 kg $ha^{-1}d^{-1}$ for mustard and 174-189 kg $ha^{-1}d^{-1}$ for flax. Maximum nutrient uptake usually occurred at flowering to seed filling stage (59-85 days after emergence. Maximum nutrient uptake rate for N, P, K, S and B, respectively, was 2.3-4.5, 0.3-0.5, 2.5-5.7, 0.7-1.1 and 0.005-0.008 kg $ha^{-1}d^{-1}$ for canola, 2.3-3.9, 0.4-0.5, 2.6-4.9, 1.2-1.4 and 0.006-0.008 kg $ha^{-1}d^{-1}$ for mustard and 3.2-4.0, 0.3-0.4, 2.9-4.1, 0.3-0.5 and 0.004-0.009 kg $ha^{-1}d^{-1}$ for flax. Both seed yield and nutrient uptake in seed were lower in 1999 than in 1998, due to differences in weather conditions in the growing season 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 grain 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 oilseed crops under conditions of optimal nutrition.

Materials and Methods

Field experiments were conducted in 1998 and 1999 on a Black Chernozemic soil. Precipitation in the growing season from seeding to harvest was 146.0 mm (150.2 mm for flax) in 1998 and 188.8 mm (211.8 mm for flax) in 1999. Treatments included crops of canola (Quest and RR Polish in 1998, Quest and 41P51 in 1999), mustard (AC Vulcan) and flax (Norlin in 1998 and Normandy 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. Oilseed crops usually reached their maximum biomass at medium to end of pod forming growth stage (75-82 days after emergence), with maximum biomass accumulation rate of 146-190 kg ha^{-1} d^{-1} for canola, 158-182 kg ha^{-1} d^{-1} for mustard and 174-189 kg ha^{-1} d^{-1} for flax.

Figures 2, 3, 4 and 5

Maximum uptake of nutrients usually occurred at flowering to seed filling stage (59-85 days after emergence). Maximum accumulation rate for N, P, K and S, respectively, was 2.3-4.5, 0.3-0.5, 2.5-5.7 and 0.7-1.1 kg ha-1 d-1 for canola, 2.3-3.9, 0.4-0.5, 2.6-4.9 and 1.2-1.4 kg ha^{-1} d^{-1} for mustard, and 3.2-4.0, 0.3-0.4, 2.9-4.1 and 0.3-0.5 kg ha^{-1} d^{-1} for flax.

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	Crops	Cultivar	Days for maximum biomass	Maximum biomass (kg ha^{-1})	Biomass at harvest (kg ha^{-1})	Grain yields (kg ha^{-1})	Harvest indexes
1998	Canola	Quest	84	8866	8453	2162	25.6
	Canola	RR Polish	75	6842	5281	1991	37.7
	Mustard	AC Vulcan	79	8191	7005	1982	28.3
	Flax	Norlin	80	7711	6575	2247	34.2
1999	Canola	Quest	74	6912	6461	1536	23.8
	Canola	41P51	75	6974	6647	1147	17.3
	Mustard	AC Vulcan	80	7159	7137	1345	18.9
	Flax	Normandy	79	6765	6128	959	15.7

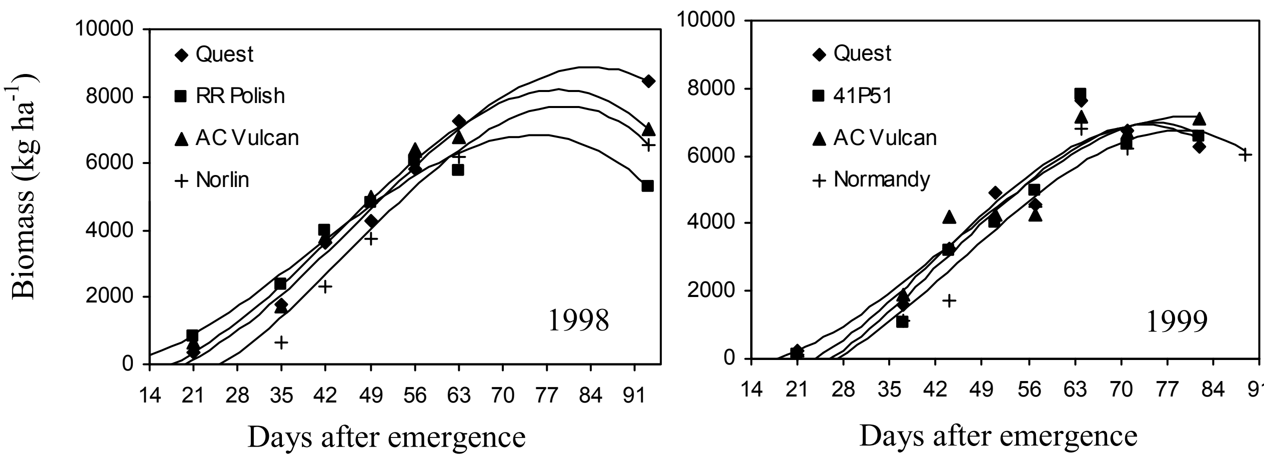

Figure 1. Changes of biomass (kg DM ha^{-1}) with days after emergence in the field experiments at Melfort, Saskatchewan.

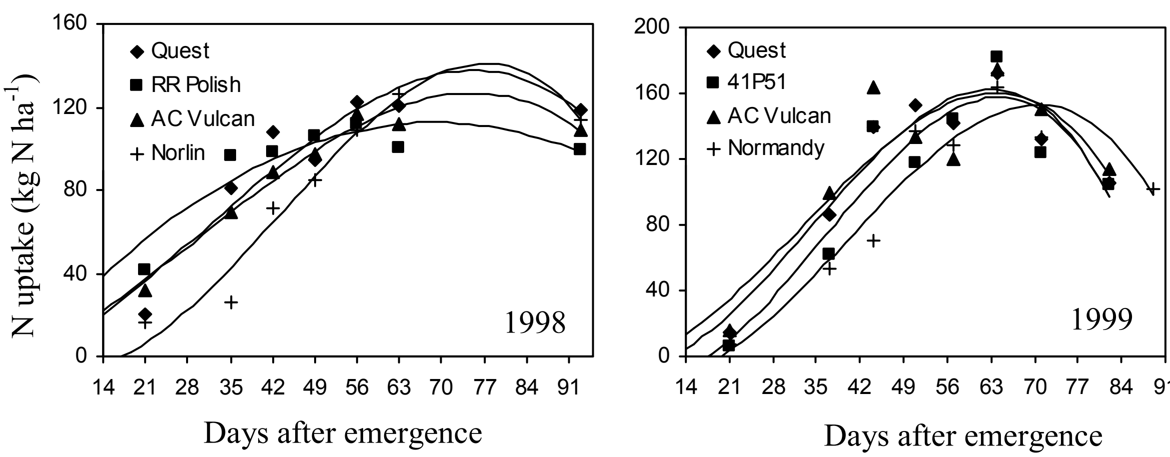

Figure 2. Changes of N uptake (kg N ha^{-1}) with days after emergence in the field experiments at Melfort, Saskatchewan.

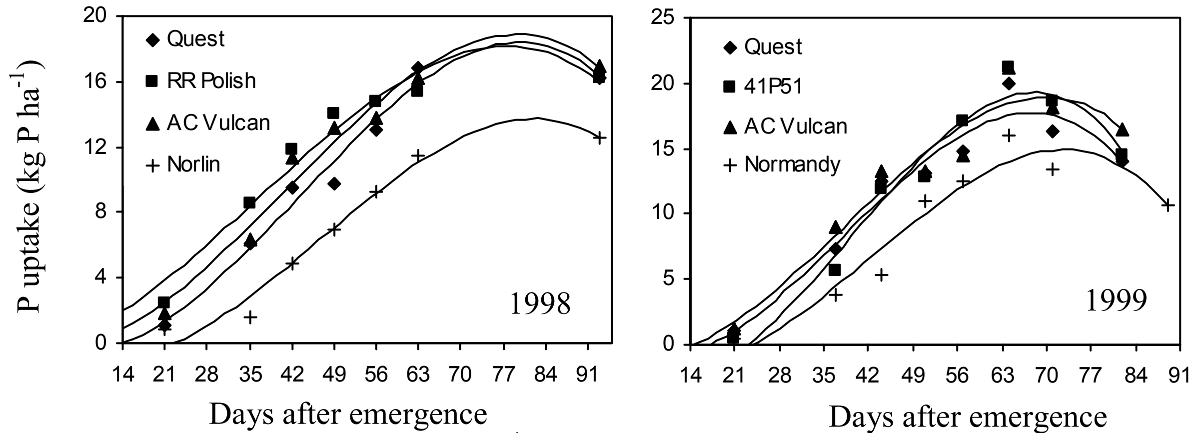

Figure 3. Changes of P uptake (kg P ha^{-1}) with days after emergence in the field experiments at Melfort, Saskatchewan.

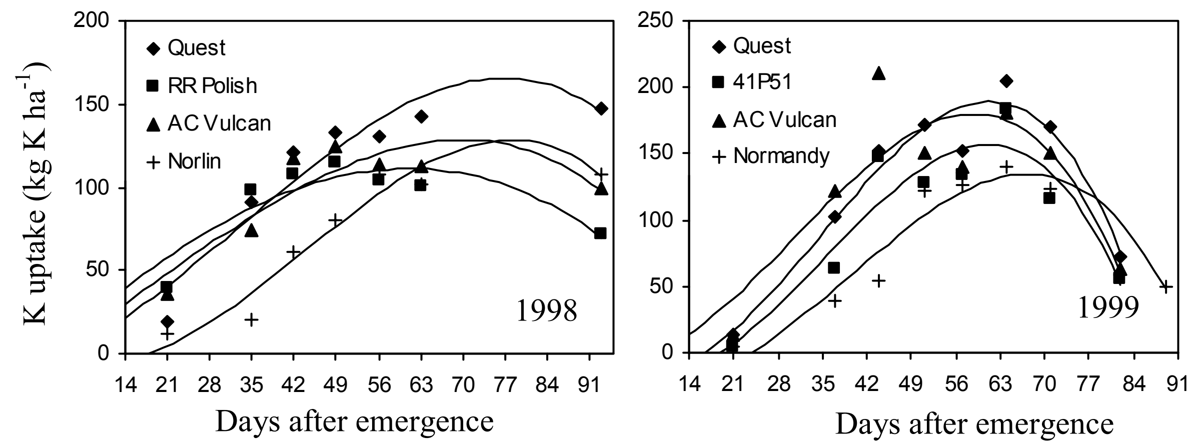

Figure 4. Changes of K uptake (kg K ha^{-1}) with days after emergence in the field experiments at Melfort, Saskatchewan.

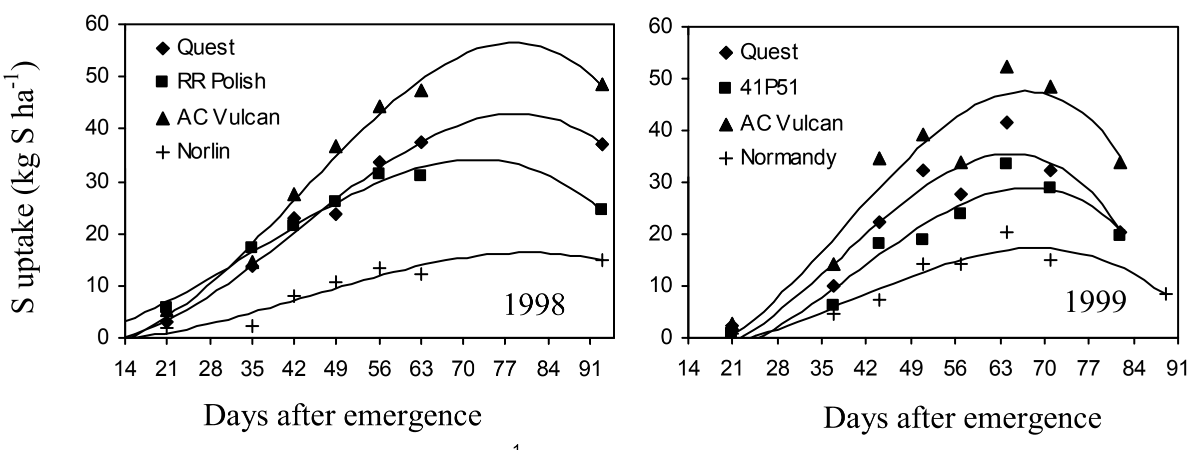

Figure 5. Changes of S uptake (kg S ha^{-1}) with days after emergence in the field experiments at Melfort, Saskatchewan.