Abstract

A commercial field of ‘Nantes’ hybrid carrots grown for seed near Madras, Oregon was sampled for nutrient uptake during the 2001-2002 growing season. Three feet of the outside female row was removed at ground level at four representative locations in the field. Total nitrogen accumulation was approximately 225 lb/acre, total K was 175 lb/acre and more than 12,000 lb/acre of biomass was generated. Biomass accumulated rapidly from early June to late July, with over three-quarters of the total biomass production occurring during this time. Peak N uptake of 2.5 lb/acre/day occurred in mid-June, at the beginning of flowering. The peak K uptake rate of 2 lb/acre/day occurred a week earlier than peak N uptake.

Introduction

Central Oregon is the major hybrid carrot seed production area supplying the domestic fresh market carrot industry. Understanding nutrient requirements for carrots grown for seed is an important component in maximizing seed production and quality. The 2001-2002 growing season was the second year of a project to determine nutrient uptake of carrots grown for seed throughout the growing season.

Our hope is to provide growers with information that will aid in making decisions about nutrient application and accumulate data that can be used in models that will be developed to predict nutrient need/supply.

Methods and Materials

Samples were collected from a commercial hybrid ‘Nantes’ seed carrot field near Madras, Oregon by harvesting 3 ft of the outside female row at ground level from the fall of 2001 through the summer of 2002. Sampling dates were November 9, March 26, April 26, May 3, May 17, June 25, July 12, August 6, and September 20. Flags were placed at four representative locations in the field and samples were collected near these flags. Samples were dried, weighed, and analyzed for N, P, K, S, Ca, Mg, S, B, Mn, Cu, and Zn.

A three-parameter sigmoid equation was used to describe biomass accumulation and nutrient uptake (Fig. 1). The first derivative of the equation was taken to determine a rate function, dN/dt. An estimate of maximum time of biomass or nutrient accumulation can be estimated by plotting the rate function vs. sampling date (Fig. 2).
Results and Discussion

Average biomass and nutrient accumulation for each sampling date is presented in Table 1. The end of season biomass amount, 6 ton/acre was greater than the 4 ton/acre reported last year (Butler et al, 2002). The carrot variety was not the same each year and this was the expected primary reason for the difference in biomass accumulation. The peak nitrogen accumulation, approximately 225 lb/acre, is consistent with the amount found in many other crops grown in the northwest (Sullivan & Christianson, 1999). The peak or largest amount of nitrogen was measured before harvest and is also consistent with measurements made in other crops grown for seed. Lower leaves are shaded, senesce, and are sloughed by the plant. The cumulative effect is a measured loss of above-ground nitrogen accumulation.

Table 1. Average above-ground biomass and nutrient accumulation of ‘Nantes’ hybrid carrots grown for seed in central Oregon. Carrot seed was planted in 2001 and harvested in 2002.

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th>Biomass Accumulation</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Ca</th>
<th>Mg</th>
<th>B</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/19/01</td>
<td>420</td>
<td>15</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>3/26/02</td>
<td>574</td>
<td>16</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>7</td>
<td>2</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>4/26/02</td>
<td>452</td>
<td>45</td>
<td>5</td>
<td>33</td>
<td>6</td>
<td>26</td>
<td>9</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>5/17/02</td>
<td>1151</td>
<td>58</td>
<td>3</td>
<td>21</td>
<td>3</td>
<td>17</td>
<td>6</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>6/25/02</td>
<td>958</td>
<td>149</td>
<td>17</td>
<td>121</td>
<td>18</td>
<td>88</td>
<td>27</td>
<td>0.23</td>
<td>0.19</td>
</tr>
<tr>
<td>7/12/02</td>
<td>7292</td>
<td>158</td>
<td>19</td>
<td>122</td>
<td>21</td>
<td>106</td>
<td>31</td>
<td>0.28</td>
<td>0.21</td>
</tr>
<tr>
<td>8/6/02</td>
<td>12096</td>
<td>225</td>
<td>29</td>
<td>175</td>
<td>36</td>
<td>192</td>
<td>52</td>
<td>0.48</td>
<td>0.35</td>
</tr>
<tr>
<td>9/15/02</td>
<td>12070</td>
<td>211</td>
<td>28</td>
<td>136</td>
<td>33</td>
<td>209</td>
<td>54</td>
<td>0.54</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Potassium accumulation, 175 lb/acre, is less than the 200 lb/acre measured last year. This measurement is curious since the biomass is so much larger this year than last year. The amounts of other nutrients reported in Table 1 are higher for the 2001/2002 growing season than for the 2000/2001 season. This trend is logical and consistent with the biomass production.
Figure 1. Total biomass and nitrogen accumulation for Nantes hybrid carrots produced for seed in 2001/2002 growing season.

**Biomass**
Seed carrots grew slowly in the fall and spring, producing only 500-1,000 lb biomass/acre by late April or early May (Fig. 1a). From early to mid-June through mid-to late July, the growth was rapid and linear, accounting for two-thirds to three-fourths of the total biomass. Less than 20 percent of the biomass was produced after late July in 2002. Peak biomass production of 150-200 lb/acre/day occurred in late June. Growth of carrots for seed slowed after seed set. Compared to the previous growing season, seed carrot growth in the 2001-2002 season began earlier, had a lower peak rate, and continued growing later. The peak growth time, mid- to late June, was the same in both years. Growing Degree Days (data not shown) were comparable for both seasons. Slight hail damage occurred in late May of the 2000-2001 season and might have contributed to the apparent slower early season growth, sharp increase in growth during June, and peak growth rate of more than 200 lb/acre/day. Even considering the hail-influenced growth in 2000-2001, the primary reason for the growth dissimilarity measured was probably from varietal difference.

**Nutrients**
Nitrogen uptake was rapid during May and June, essentially complete by early August, approximately 5-6 weeks before harvest (Fig. 1b). The amount of N taken up by carrots grown for seed is variety dependent, primarily a function of biomass production. Total N uptake was approximately 175 lb N/acre in the 2000-2001 growing season and approximately 225 lb/acre in the 2001-2002 growing season.
Figure 2. Daily accumulation of biomass, nitrogen, potassium, and sulfur for ‘Nantes’ hybrid carrots grown for seed in the 2001-2002 growing season.

Peak N uptake of 2.5-3.5 lb/acre/day occurred in mid- to late June both years. The peak N uptake rate occurred as bloom was beginning and before bees were placed in the field. The maximum biomass production was estimated to occur one to two weeks after the maximum rate of N accumulation was achieved.

The peak uptake rate of potassium and sulfur preceded the peak production of biomass in the 2001-2002 growing season. During the 2000-2001 growing season, the potassium uptake rate was 2 lb/acre/day more than N, but less than N in the 2001-2002 growing season.

Management
After seed set, nutrient uptake decreases rapidly as seed carrots enter Phase III growth, redistribution of nutrients. Nutrients should be supplied well in advance of need, early to mid-May at the latest. If sufficient nutrients are supplied during the early growing season, late season applications are not efficient or effective. Some N should be applied in mid- to late-April to support early growth. The bulk of the N is accumulated during June. A combination of available soil and fertilizer N totaling 150 to 200 lb/acre seems a logical rate. Seed carrots grown in central Oregon are often planted in fields where Kentucky bluegrass seed was produced. Decomposition of perennial grass sod provides a substantial amount of N to the following warm season crop. Even though 200 lb/acre N is used by a carrot seed crop, it may be produced with the application of half or less of that amount when following a perennial grass rotation.

References