**Effects of Bulb Planting Date on Growth of Tulip 'Don Quichotte' under Mild Winter Conditions**

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**Abstract**  
For tulip bulb production it is recommended not to plant the bulbs when soil temperature is high (> 12-13°C). This is due to the risk of *Fusarium* contaminations. In areas with mild Winters, generally associated with warm Autumns and warm Springs, planting dates can be as late as December. In order to determine the effects of planting date under such climatic conditions, bulbs were planted in October, November, and December. The growth of the various organs of the plants (roots, aerial parts, daughter bulbs) was recorded. Late planting resulted in: 1) a reduced root growth, 2) a very slight delay in flowering, 3) a reduction in plant height and aerial part weight, and 4) a delayed daughter bulb enlargement.

**INTRODUCTION**  
For tulip bulb production, the bulb planting period is mainly determined by two factors; (1) soil type, in relation to the risk of soil compaction and (2) soil temperature. In order to minimize the risk of infections by *Fusarium*, soil temperatures at the bulb planting depth should not be higher than 13°C (De Hertogh et al., 1983; Le Nard and De Hertogh, 1993; Bakker, 1999). Thus, planting date is strongly regulated by soil temperature and, according to the climatic conditions, differences in the planting periods are observed. In The Netherlands, soil temperatures near 13°C can be observed by mid-October (Bakker, 1999). However in areas with warm Autumns, like Southwest and Southeast France, these soil temperatures are not observed before December. In those areas, Winter is rather mild and Spring can be very warm. Thus the risk of infection by *Fusarium* is very high. In order to try to reduce it, growers generally plant the bulbs late, i.e., in December. The effects of late planting period on tulip growth is not well documented. The purpose of the experiments reported was to determine the effects of bulb planting date on the growth of the different plant organs, e.g., roots, aerial parts, and daughter bulbs.

**MATERIAL AND METHODS**  
Bulbs of tulip cultivar Don Quichotte, 10/11 cm in circumference, were harvested on 22 June. They were subsequently stored at 22°-25°C until 12 July, 20°C until 10 October, 18°C until 3 November, and 17°C until the last planting date. Bulb samples were planted on 15 October (P₁), 15 November (P₂), and 15 December (P₃). In order to make root harvest easier, planting was done in pots containing vermiculite. Five bulbs were planted per 5 liter pot. The pots were placed in an open plastic tunnel, at I.N.R.A., Ploudaniel.

During the growing period, a minimum of 20 plants per planting date were harvested monthly, until 15 May. At each harvesting date, until 15 April, roots were collected and their fresh and dry weights were recorded. The growth of the aerial parts was recorded from 15 January until flowering. The length of the aerial parts (leaves, flower scapes) was measured from the basal plate. After reaching full flower, the heads were removed. The daughter bulbs were collected on 15 March, 15 April, and 15 May and their fresh and dry weights were recorded.
RESULTS

Root Growth
The rates of root growth, expressed in the dry matter weight per plant, are presented on Figure 1. It appears that although root growth started slowly, the plants produced by the bulbs planted on 15 October (P1) exhibited the earliest root growth and the highest final root growth. Root growth was weakest in plants produced by the bulbs planted on 15 December (P3). The root growth in the plants produced by the bulbs planted on 15 November (P2), was intermediate between P1 and P3, but closest to P1.

Aerial Part Growth
On 15 January, the average lengths of the flower buds respectively of the three planting dates were very similar (Fig. 1). The plants of P1 exhibited the fastest growth, while the P3 plants had the slowest growth. The P2 plants had an intermediate position. Flowering was observed on 25 March for P1, on 27 March for P2, and on 3 April for P3. Thus there were only small differences in the flowering dates of the plants from the three different planting dates (Fig. 1).

At flowering, before flower removal, the length of the flower scapes was measured (Table 1). The average values were: 51.2 cm for P1, 45.4 cm for P2, and 32.2 cm for P3. Thus, as the planting date was delayed the flower scapes became shorter.

Planting date also affected the length of the leaves at flowering (Table 1). The difference between flower scape length and leaf height (uppermost leaf tip) decreased as the planting date was delayed.

Planting date not only affected the length of the aerial organs but also their weight (Table 2). The highest weight of the aerial organs, measured at full plant growth on 15 April, was observed for the P1 plants. The lowest was observed for the P3 plants. The P2 plants had an intermediate position. Thus it appears that the latest planting date produced the least vigorous plants.

Daughter Bulb Growth
Daughter bulb enlargement started just before flowering and the main growth took place after flowering. The results (Figure 1) indicate that daughter bulb enlargement was clearly delayed by late planting, P3. The differences between P1 and P2 were small. On 15 May, daughter bulb growth in the plants produced by P3 was much less than in plants produced by P1 and P2. This was true for the main daughter bulb as well as for the other secondary daughter bulbs. Dry matter weight per plant for the secondary daughter bulbs was 0.8 g for P1, 0.7 g for P2, and 0.5 g for P3.

DISCUSSION
This study shows that under conditions characterized by a warm Autumn, a mild Winter, and a warm Spring, bulb planting date clearly affects the growth of the different plant organs. It appears that late planting, (15 December) leads to a reduction in root growth (Fig. 1). Consequently, the roots produced by these bulbs occupy a reduced soil volume when compared to earlier planted bulbs. For the three planting dates, active root growth stopped or was strongly reduced when active growth of the aerial parts occurred (Fig. 1). It was observed that the flower buds, independently of planting date, showed an active growth after the middle of January. However, subsequent growth rate and the length of the flower scapes at flowering were affected by the bulb planting date. The fastest elongation and the longest scapes at flowering were observed in the plants from the earliest planting date (Fig. 1). Conversely, the latest planting date induced slower elongating plants and shorter plants at flowering. An explanation for such results could be: (1) the plants from the latest planting date were subjected during a shorter period to low/cool temperatures and (2) their flowering (anthesis) was hastened by the high temperatures after end March and beginning of April. These differences resulted in the production of less vigorous plants after a delayed bulb planting date (Table 2). Another
important point, for commercial bulb production, was the effects of planting date on the length of the flower scape when compared to the length of the leaves (Table 1). To allow a mechanical removing of the flowers without damaging the leaves, the base of the flowers must be above the tips of the leaves. The results (Table 2), indicate that delayed bulb planting reduced the difference between flower scape length and leaf height. This was confirmed in other experiments (unpublished results) using 'Gander', and 'Lustige Witwe'. For these cultivars, bulbs planted in early and mid-December produced plants whose flowers were still into the leaves at flowering time.

Daughter bulb growth was also strongly affected by planting date (Fig. 1). The latest planting date produced delayed and reduced daughter bulb growth. This could be due to the fact that the plants produced by late planted bulbs are less vigorous (Table 2). Also, that in these plants active daughter bulb growth took place during a period when air temperatures were high. Daughter bulbs require an optimum between 12° and 15°C for their development (Schenk, 1969; Kronenberg, 1977). The results reported for 'Don Quichotte', have been confirmed in other experiments with 'Gander', 'Lucky Strike' and 'Lustige Witwe' (unpublished results).

In conclusion, it appears that in areas with mild Winter and warm Spring, delayed plantings (up to mid-December) negatively affect tulip plant and root growth. The plants were less vigorous and daughter bulb production was also reduced. Under these climatic conditions, minimizing the risk of infections by *Fusarium* and obtaining good bulb production are not compatible. The results reported are, of course, based on one growing season. However, additional experiments during three different growing seasons (unpublished results) indicate that the conclusions presented are valid. The effects of planting date were pronounced, depending on the climatic conditions during the growing period, and the trends were always similar.

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Literature Cited
Tables

Table 1. Effects of bulb planting date on the average length of flower scapes and leaves on date of full flower of tulip 'Don Quichotte'.

<table>
<thead>
<tr>
<th>Planting date</th>
<th>Flower scape</th>
<th>Uppermost leaf tip</th>
<th>Differential</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 October</td>
<td>51.2</td>
<td>44.5</td>
<td>+ 6.7</td>
</tr>
<tr>
<td>15 November</td>
<td>45.4</td>
<td>41.6</td>
<td>+ 3.8</td>
</tr>
<tr>
<td>15 December</td>
<td>32.2</td>
<td>32.6</td>
<td>- 0.4</td>
</tr>
</tbody>
</table>

Table 2. Effects of bulb planting date on the weight of the aerial organs of tulip 'Don Quichotte'.

<table>
<thead>
<tr>
<th>Planting date</th>
<th>Average dry matter (mg/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 March</td>
</tr>
<tr>
<td>15 October</td>
<td>2610</td>
</tr>
<tr>
<td>15 November</td>
<td>1800</td>
</tr>
<tr>
<td>15 December</td>
<td>1145</td>
</tr>
</tbody>
</table>

Figures

Fig. 1. Effects of bulb planting date on growth of tulip ‘Don Quichotte’. 
?: P1: 15 October; ?: P2: 15 November; ?: P3: 15 December
?: Flowering