Effects of shoot, root and stolon temperature on the development of the potato (Solanum tuberosum L.) plant. II. Development of stolons

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Summary

Cultivars Bintje and Désirée were grown in a multi-compartment set-up, which allowed different shoot, root and stolon temperatures, to study the effects of temperature around different plant organs on the development of stolons.

A high root temperature induced orthotropic stolon growth in cv. Bintje.

Stolon number was not affected when temperature was increased in one compartment only, but high root temperature combined with high stolon temperature or high air temperature reduced stolon number. For 'Bintje', branching of stolons and their dry-matter yield were enhanced by a high temperature in each compartment, but combining high air temperature with another temperature increase was detrimental.

Stolon initiation was less synchronized when plants were exposed to both high air temperature and high stolon temperature.

The hormonal regulation of stolon formation and the effects of temperature on the hormonal balances involved are discussed.

Introduction

High temperatures are often a major constraint for the production of potatoes in the lowland tropics, since they impede the production of dry matter, tuberization, and dry matter partitioning to the tubers. However, cultural practices that affect the diurnal fluctuation of temperature or the temperature around certain parts of the potato plant, can be used to overcome the inhibition of tuberization by heat.

The induction, initiation, growth and subsequent inhibition of elongation of stolons are crucial steps in the tuberization process of potato plants (Vreugdenhil & Struik, 1989). The regulation of these processes and the effects of environmental factors on stolon development are poorly understood.

High air temperatures stimulate the development of stolons (Bodlaender et al., 1964; Burt, 1964; Saha et al., 1974; Moorby & Milthorpe, 1975) and also favour stolon branching. Some reports indicate that high soil temperatures tend to reduce the number of stolons or the stolon yield (Randeni, 1980; Lemaga, 1986). Midmore (1984) reported that stolon development was delayed but that the final number of stolons and the final stolon yield were increased by high soil temperatures, findings in agreement with those of Mosille (1985).
In an earlier paper (Struik et al., 1989) we reported the effects of temperature in the environments of the shoot, the roots and the stolons, on the development of the haulm. This paper deals with the effects on stolon development.

**Materials and methods**

Several similar experiments were carried out. Because the results were very similar only the most comprehensive and illustrative experiment is described and in which ‘Bintje’ and ‘Désirée’ were used.

*Growing of plants and treatments.* The general set-up, the statistical design, the growing of the plants and the treatments were as described by Struik et al. (1989). The temperatures in the different compartments are listed in the tables. Stolon temperatures are based on measurements at a depth of 0 cm (Struik et al., 1989).

*Measurements.* The stolon medium was removed by means of a vacuum cleaner about twice a week. All new stolons were tagged and dates of first observation were recorded as dates of initiation. After the observations the stolon medium was rewetted and replaced.

Stolons that showed orthotropic growth and finally produced above-ground leaves were called wild stolons.

The initiation of tubers was also recorded. A tuber was defined as a swelling of a stolon tip with a diameter of at least 5 mm.

The duration of stolon growth was defined as the period between the first date of observation of the stolon and the date of initiation of the first tuber on that stolon.

The dry weights of four selected stolons (numbers 4, 5, 6, and 7 when ranked in the order of date of initiation) were assessed after drying for 24 h at 105 °C in a forced ventilated oven.

**Results**

The tips of large stolons were sometimes induced to cease plagiotropic growth. Such orthotropic (‘wild’) stolons mainly occurred in cv. Bintje (Table 1) in which a high root temperature stimulated their occurrence (Table 1), resulting in a significant interaction between root temperature and cultivar (Table 2).

There were also large differences in the number of stolons (Table 1). Overall, ‘Désirée’ had fewer stolons than ‘Bintje’. For ‘Bintje’, increasing the shoot, root or stolon temperature hardly affected the number of stolons whereas an increase in air temperature reduced the numbers in ‘Désirée’. Combinations of temperature increases, however, had large effects on the numbers, the combination of high shoot and root temperatures proving especially detrimental. Using the abbreviations given in Table 2, the interactions $R \times C$ and $A \times R \times C$ were significant (Table 2). When the root temperature was low, the effect of an increased shoot temperature was larger for ‘Désirée’ than for ‘Bintje’.

The potential number of tuber sites on the stolons correlated closely with the number of stolons (simple linear correlation coefficient $r = 0.882; n = 16; P<0.001$), but this parameter was more markedly affected by root temperature and had many more significant interactions (Tables 1 and 2). Three of the four possible three-way interac-