Influence of bud position on the formation of tubers on multiple node cuttings of potato (*Solanum tuberosum* L.)

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Date of acceptance: 4 December 1998

Additional keywords: bud position, gravity, leaf position, sink-sink interaction, stem cutting, stem orientation, tuberization

Summary

Stem cuttings with variable number and position of leaves and variable number and age of buds were used to study the preference of tuberization at certain buds when several potential tuber sites were present. These cuttings were exposed to different orientations of the cuttings themselves and/or their light source.

Inverting the cuttings did not affect overall tuberization, but had significant effects on individual buds, probably by the interaction between the original basipetal patterns in the cuttings and gravity effects. A smaller angle to the horizontal and lighting from below increased the overall expression of the tuberization stimulus. Leaf and bud position or age affected expression in a complicated manner, but the distance between screened bud and light-exposed leaf was crucial; buds most distant from illuminated leaves showed the strongest induction. The basic pattern of tuberization was basipetal.

Introduction

Tuberization is an important step in the development of the potato plant. The process results from a precisely orchestrated sequence of physiological events which are all affected by complex mechanisms under the control of (different) hormones or hormonal balances (Vreugdenhil & Struik, 1989; Ewing & Struik, 1992; Vreugdenhil & Helder, 1992; Vreugdenhil, 1998). Gibberellins seem to be crucial for many of these mechanisms (Vreugdenhil, 1998). Quantitative trait loci (QTL’s) with effects on tuberization are located on different chromosomes (e.g. van den Berg et al., 1996), suggesting that the genetic control is also complex.

Understanding tuberization is important. The process of tuberization triggers a series of changes in the behaviour of the potato plant which not only dramatically change the development of stolon tips and dry matter partitioning, but also affect the entire morphology, phenology and physiology through to senescence. More information on tuberization and its physiological and genetic control would allow us to develop strategies for improved agro-ecological adaptation of the potato crop to adverse conditions and to improve the phenological adaptation of cultivars to their growing conditions. At the same time it would open avenues for optimizing crop management for higher yields and the proper manipulation of tuber number and tuber size distribution; also for improving control of physiological disorders such as growth cracks, second growth, misshapen tubers and the chemical composition of...
marketable tubers (dry matter content, sugar content, etc.). Finally, it would allow further improvement of rapid (in vitro) multiplication techniques.

Stem cuttings are convenient models of the entire potato plant and have been used extensively to study tuberization and other physiological phenomena in potato (Ewing, 1985; Ewing & Struik, 1992; van den Berg et al., 1990; McGrady & Ewing, 1990). They accurately simulate processes in the complete plant and can reliably characterize the potential behaviour of genetically unique individuals without sacrificing them entirely. Because of their simple structure and physiological independence from the mother tuber, they might also show clearer responses than the whole plant from which they were taken. Moreover, they are easier to manipulate (for example with hormone treatments or exposure to inverted gravity), and can be checked for tuberization frequently and non-destructively. With proper handling and pre-treatment of explants or propagules, source plants and cuttings, the onset and site of tuberization are highly predictable and therefore cuttings can also be used for detailed analysis of the sequence of physiological events associated with tuberization (Duncan & Ewing, 1984; Vreugdenhil & Helder, 1992; see also Visser et al., 1994; Sanz et al., 1996).

Depending on research objectives, special cuttings can be designed with varying numbers of nodes, number of nodes in the dark, number and position of leaves, etc. Stem cuttings with more than one potential tuber site may be helpful in studying patterns and localization of tuberization, or to gain insight into sink-sink and source-sink relations.

Previous research, mainly by the group of Ewing et al. (for an overview see Ewing, 1985) has indicated that light is a crucial factor. Screening buds plus the adjacent stem from light triggers tuberization, but only if cuttings are induced by correct photoperiod treatment, i.e. they are taken from induced plants or contain leaves that can be exposed to inducing conditions after cutting (Purohit, 1970; Ewing, 1985; Hammes & Beyers, 1993). However, the presence of large stem pieces buried deeper than the bud impedes tuber formation on the bud (Kahn & Ewing, 1983) and may result in swelling of the stem piece or starch accumulation in that part of the cutting. Therefore, the buried stem parts beyond the bud can act as an alternative sink for tuberization stimulus and growth factors, and therefore impede tuberization on the buds. A second important factor is the presence of leaves: number, age and size of the leaves present on the cutting all affect tuberization (Kahn et al., 1983). Leaf area available as a source of assimilates and other growth factors should have a minimum size, whereas the leaves should not be too young (i.e. not properly induced) or too old (not enough export to the bud).

When several buds are present as potential tuber sites, the distance from the buried node to the light-exposed stem or leaf is important. There is strong preference for the deepest buried buds; also the longer the distance, the higher the frequency of tuberization, both with normal and with inverted cuttings. The mechanism of this effect is still unclear; it could be partly associated with gravity or with bud age (for overview see Ewing, 1985). However, the effects of these factors are easily overruled by other factors. For example, Hammes & Beyers (1993) recently showed that gravity had little effect.