Potato Research (2007) 50:309–313
DOI 10.1007/s11540-008-9084-3

The Canon of Potato Science:

26. *In Vivo* Cuttings

W. J. M. Lommen · P. C. Struik

Published online: 19 May 2008

What are they?

Cuttings are pieces of plant material usually taken from plants for further multiplication. In potato, they generally consist of a part of the stem or sprout, containing at least one bud and often the accompanying leaf. The cuttings are rooted, the buds develop into new shoots, and the resulting plantlets are transplanted into the field or glasshouse for tuber production and/or continued production of cuttings. In other plant species cuttings may also consist of plant parts without existing buds, e.g., leaf or storage root parts. However, the use of (pre)differentiated or predestined buds for further multiplication reduces the chance of genetic drift (i.e. the chance of obtaining genetically aberrant individuals).

The potato plant is very versatile, and its buds can develop into several types of modified stems: sprouts, shoots, stolons and tubers. On the other hand, buds from very different structures, such as stems, stolons, tubers, or inflorescences can produce tubers. Whether there is development of a structure and which structure develops from the buds of cuttings depends on the history of the plant from which the cutting is taken and the history of the bud itself, but also on the conditions under which plant and bud were produced, the prevailing external conditions after taking the cutting, the genotype and the type of cutting taken. When the degree of tuber induction of a mother plant increases, buds develop more frequently into stolons and then into tubers instead of into shoots. This varying response in bud outgrowth of cuttings is not only used for vegetative multiplication, but also in physiological studies to increase our knowledge on stolon and tuber formation, and as a selection tool in breeding.

We describe here six types of cuttings: apical cuttings, stem cuttings, single-node cuttings, leaf-bud cuttings, sprout cuttings and multiple-node cuttings, and their use.

W. J. M. Lommen (✉) · P. C. Struik
Crop and Weed Ecology, Wageningen University, P.O. Box 430, 6700 AK Wageningen, The Netherlands
e-mail: willemien.lommen@wur.nl

Apical cuttings are taken from the top of the shoots. They are used in research and for multiplication purposes. They may vary from very small (as in meristem culture *in vitro*) to 10ths of cm large.

Stem cuttings are a type of apical cuttings, used in multiplication. They typically consist of the apical whorl with 1–3 lower leaves. For production of stem cuttings, the main stems of potato plants are decapitated when they are 20–30 cm large to induce branching. When the branches have attained an appropriate size (after 1–2 weeks), the apical parts (c. 8–15 cm) are cut and rooted: the stem cuttings. The nodes remaining on the branches can produce a new flush of shoots for subsequent cutting. Mother plants are sometimes treated with gibberellic acid to enhance branch development. Cuttings are often treated with hormones (auxins) to stimulate rooting.

Single-node cuttings consist of a stem part containing a single leaf and its subtending bud. The bud will develop into a new shoot when the mother plants from which the cutting was taken were not yet (strongly) induced to tuberize. Higher positions closer to the apex increase the chance of successful shoot formation. Single-node cuttings form the basis of most *in vitro* multiplication systems, but are more risky *in vivo*, because the buds easily develop into stolons, tubers and intermediate forms depending on the degree to which the mother plants were induced to tuberize. This sensitivity makes single-node cuttings convenient tools in research studying tuber induction of potato plants, a phenomenon which cannot be assessed directly. For multiplication, single-node cuttings are taken *in vivo* from young, well fertilized plants with 5–6 leaves. The stem part is removed leaving at least one strong bud to produce a new shoot. The removed stem is dissected into the single-node cuttings. Also the apical part is normally used. After 15–20 days, single-node cuttings can be taken again from the newly produced shoots of the same mother plants. This might be repeated 2–10 times.

Leaf-bud cuttings are similar to single-node cuttings and the terms leaf-bud cuttings and single-node cuttings are interchangeably used in research. In multiplication, however, the end products of leaf-bud cuttings are small tuberlets and not rooted plantlets. Leaf-bud cuttings are produced from plants that have been grown under tuber-inducing conditions, like a moderate temperature, short photoperiod, limited N fertilization for at least 2 weeks, and/or from relatively old seed tubers. The bud then differentiates into a tuber instead of into a shoot.

For multiplication studies, single-node and leaf-bud cuttings are always prepared using a piece of stem, but for research in which cuttings are used as a tool to study tuber induction, the stem piece is usually trimmed away as much as possible without damaging the bud, to avoid having an alternative sink for starch accumulation.

Sprout cuttings are single-node cuttings prepared from tuber sprouts. To prepare sprout cuttings, the mother tuber is sprouted (usually at room temperature) under alternating dark and light conditions, e.g. 1 week darkness, 1 week indirect light. In the darkness the sprouts elongate and during the light phases, elongation is suppressed and anthocyanin and glycoalkaloids can be formed that make the sprouts less susceptible to attack by diseases after planting. The alternating light and dark conditions are necessary to balance elongation. Only darkness would lead to very thin, too long, and too delicate sprouts that will not easily survive. Only light will

lead to sturdy but stocky sprouts with nodes too close to cut and/or handle. Root initials are usually clearly visible on the sprouts at the lower part of the node, especially at relatively high air humidity during sprouting. When taking the cuttings, whole sprouts are removed from the tuber leaving some lower buds to produce a new flush of sprouts. The removed sprouts are cut a few mm above each node. The cutting is planted in the rooting medium with the node at the ground level, so that the root initials and bud just touch the soil, and the upper few millimetres of the stem part of the cutting above the surface. Sprout cuttings generally root readily because of the preformed root initials and need no rooting hormones. The apical parts of the sprouts can also be planted, but will grow faster than the cuttings from the single nodes. Sprout cuttings have the advantage that the tubers they are produced from do not need planting in soil, that they occupy little space in the rooting phase, and that they almost always successfully grow into shoots.

Multiple-node cuttings are mainly used in research. They contain several internodes, buds and often one or more leaves. They even may consist of several branches, but have no apex. They offer the possibility of studying the effect of position of a leaf or a bud on patterns of tuber formation, the interaction between different buds of different ages or position, and sink-sink or sink-source relationships. In specific forms they may even be used to study tuber size distribution.

In types of cuttings where one or more leaves remain attached to the structure, the size of the leaf or leaves is important. Leaves may both contain stimulants or inhibitors of tuber-forming processes and provide the necessary assimilates to support growth of the buds. In cuttings with more than one bud, the bud at the farthest distance from the leaf is usually the one showing the earliest or most advanced tuber formation.

Why are they Important in Potato Science?

Cuttings are often simple structures, with only a few types of tissues or organs, and with direct connections and relationships between buds and leaves. They usually lack the complicated process control of apices, transport systems, root systems and mother tuber. It is commonly believed that many of the changes taking place in the whole plant in response to tuber induction also take place in cuttings and are clearly reflected by direct changes in development of the buds on the cuttings. This development can be assessed and quantified, either based on a development scale or on analysis of fresh or dry matter. Using development scales, evaluation can be easy, non-destructive and even repeated over time on the same cuttings without disturbance.

As they are simple and small, cuttings can be exposed to complicated treatments in large numbers.

Plant processes and phenomena that can be studied using cuttings as models include tuber induction and initiation, secondary growth, maturation, leaf senescence, sink-sink and sink-source relations, and responses to exogenously applied growth regulators or hormones.

Why are they Important for the Potato Industry?

The *in vivo* cutting methods were developed to increase the rates of multiplication during the production of pre-basic seed as compared to the conventional clonal propagation by seed tubers. Reported multiplication factors are:

- 20–60 plants per tuber for stem cuttings;
- 25–300 plants per tuber for sprout cuttings;
- 30–200 plant per tuber for single-node cuttings; and
- 80–120 tuberlets per tuber for leaf-bud cuttings.

For production of pre-basic seed, cuttings should be taken only from healthy and true-to-type tubers and mother plants. The cuttings can also be taken from *in vitro* produced plantlets, any other type of cutting or from TPS seedlings. The stem cutting and single-node cutting methods developed *in vivo* have also been adopted for vegetative propagation *in vitro*.

Sprout and stem cuttings as the basis for seed production systems have been largely replaced by *in vitro* multiplication followed by production of minitubers, but the techniques are still extremely useful in countries or locations without *in vitro* facilities. They are also useful for rapid multiplication of selected plants, seedlings, or breeding lines.

As a research model, cuttings are useful to screen breeding populations for their critical photoperiod that controls tuberization. However, single-node cuttings do not necessarily reflect the stage of tuber formation of the plants from which they are taken. For example, single-node cuttings taken from late maturing cultivars exposed to long days do not produce tubers even when their mother plants are old enough to have started tuber bulking. Single-node cuttings of early maturing cultivars already start to produce tubers even before the mother plants from which they are taken start tuber formation.

Scientific Developments

Cuttings are used to study the physiological effects of conditions and treatments to which their mother plants or the cuttings themselves are exposed. They can be used in large-scale studies of the interaction between maturity type of the genotype, plant age, environment and management but such research should be interpreted with care.

Cuttings might also be used in physiological-genetic studies on the relationships between different factors that can be simultaneously manipulated and evaluated on one and the same cutting. An example of such an approach could be the study of the relationships between earliness of tuberization (or maturity type of genotypes) and late blight susceptibility by exposing plants from different genotypes to different regimes of photoperiod and inoculating the cuttings taken from those plants with *Phytophthora infestans* inoculum. By measuring the lesion growth rate on the leaflets of the cutting and assessing the development of the bud the physiological-genetic linkages between maturity type and late blight resistance can perhaps be established.

Further Reading

Bryan JE, Meléndez GN, Jackson MT (1981) Sprout cuttings, a rapid multiplication technique for potatoes. CIP Slide Training Series: Series I: Rapid Multiplication Techniques. Guide-Book I/1. International Potato Center (CIP), Lima

Bryan JE, Jackson MT, Quevedo BM, Meléndez GN (1981) Single-node cuttings, a rapid multiplication technique for potatoes. CIP Slide Training Series: Series I: Rapid Multiplication Techniques. Guide-Book I/2. International Potato Center (CIP), Lima

Bryan JE, Meléndez GN, Jackson MT (1981) Stem cuttings, a rapid multiplication technique for potatoes. CIP Slide Training Series: Series I: Rapid Multiplication Techniques. Guide-Book I/3. International Potato Center (CIP), Lima

Ewing EE (1985) Cuttings as simplified models of the potato plant. In: Li PH (ed) Potato physiology. Academic Press, Inc., Orlando, pp 153–207

Quevedo BM, Bryan JE, Jackson MT, Meléndez GN (1981) Sprout cuttings, a rapid multiplication technique for potatoes. CIP Slide Training Series: Series I: Rapid Multiplication Techniques. Guide-Book I/4. International Potato Center (CIP), Lima