11. Notes on the Propagation of Sweet Potato, *Ipomoea Batatas* Lam. I. The Adventive Bud Formation in the Root-Tuber.

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In *Ipomoea Batatas* there are two modes of propagation, one by adventive bud formation in the root-tuber and the other by the adventive root formation in the runner. Here in this paper we are to concern with the former. The adventive buds are produced in the tissue adjacent to or related to the base of lateral roots, and serve for propagation of runners.

The primary xylem in the root-tuber is generally pent- or hexarch, consequently the root-tuber may be said to have a sectorial structure, each sector being supplied with a primary xylem; and the lateral roots, their scars and the adventive buds are all found in 5 or 6 longitudinal rows on the root-tuber.

The adventive bud formation is a result of the traumatic reaction, as will be treated further below. The growth in thickness of the lateral roots is insignificant, so that the lateral roots are slender and are easily damaged or broken by handling in the field. In response to the stimulation of the damage there appear the initial cells for the formation either of the secondary roots or of the adventive buds; the former develops in the wet or moist condition, while the latter in dry or nearly dry condition as is easily demonstrated by the experiments (Fig. 1). Therefore there is no definite tendency of forming a bud-primordia or root-primordia, the humidity of the substratum being a determining factor.

The bud primordia on the root-tuber are generally formed after the root-tubers were harvested; in rare cases the buds are developed in the soil, when the root-tuber and the lateral roots are injured,

Fig. 1. A proximal portion of a root-tuber showing adventive buds (a, b) formed in a dry dark place and adventive roots formed after the tuber was transferred to a moist chamber; c, young secondary root swollen after the tuber was placed again in a dry place.

and probably get dry in the soil. In a number of days after the harvest the cell divisions take place in the tissue of the root-tuber around the withered lateral roots and leads to the adventive bud formation.

The developmental process of the adventive bud. The growth in thickness of the root-tuber due to the cambial activity is vigorous, while that of the lateral roots is small as I have mentioned above; therefore the tissue of the root-tuber surrounding the lateral roots upheaves around the latter, consequently the latter appears as if it grows out from the bottom of a hollow space in the root-tuber. A cork layer covers the surface of the root-tuber and a parenchymatous tissue, the phelloderm, lies underneath this cork layer. The phelloderm is rich with starch grains and intercellular spaces are well developed in it. Soon after the lateral roots withered the parenchymatous cells just mentioned begin to divide around the withered root, probably being activated by the wound hormone which was produced in the dead cells of the withered lateral roots; the starch grains in those cells resolve before the active cell division sets in. Here I may expressly mention that the first visible sign of the activation in those parenchymatous tissue (the permanent tissue cells) is the resolving of the starch grains contained. The wound hormone must be either the activator for the production of a diastase or the producer of the cell condition in which the starch grains resolve. Also due to the death of the lateral root the accumulation of auxin in the tissue concerned is to be considered. The auxin from the root-tuber, which was carried down to the root tips in the life time of the lateral roots, must now stop at the region of the root scar, owing to the loss of the lateral roots. Auxin may also play a roll for the resolving of the starch grains (cf. Hirose, 1943¹⁾). In activated cells no starch grains are found, which in young cells of phelloderm close to phellogen young amyloplasts appear, by which we can easily recognize the activated new tissue. When the newly produced cells are situated at the periphery of an intercellular space they protrude into the latter, and some of them become the initial cells of the adventive bud primordia. Not all bud primordia surrounding a root scar develop simultaneously, but generally one, especially in a small root-tuber, develops faster than others. In such primordial cells the cell division occurs vigorously especially at the surface of the primordium so that it becomes a large mass of the small cells projecting into the intercellular space of the phelloderm (Fig. 2).

Thus the bud primordium is formed. When this primordium reaches a certain size there arises the differentiation of two growing points, that of the stem and of leaves. The former is the central growing point and the latter are at a certain distance from the former, developed in a definite phylotaxial order. The very early produced leaf growing points do not develop to be full grown leaves, some of them even degenerating in an early stage; but the cells of these leaf

1) Hirose, T. 1943. Shokubutu and Dobutu, 11: 697-704.

primordia grow faster than those in the central stem growing point. As the later developed leaf primordia grow larger and faster, and the growth of the cells of dorsal side of the young leaves is greater than that of the ventral side cells, the young leaves cover the central growing point of the stem as in the ordinary buds.

The usual course of differentiation of tissues in the growing points into dermatogen, periblem and plerome takes place and the further development of those into epidermis, cortex or mesophyll and stele occurs as usual. When the root-tuber is a coloured variety or clone the sub-epidermal cells of the primordial leaves are coloured more deeply than the root-tuber itself, so that the presence of the bud primordia can be easily recognized in the early stage of the development.

The cells of the dermatogen divide more frequently than those of the mesophyll and some of them protrude from the surface and grow as trichomes. The cells in the axial part of the plerome of the stem stop their division earlier than those in the periphery and form pith, while cells in the peripheral region of the plerome continue to divide longer and the conductive tissues are differentiated in it. Simultaneously with those development in the bud primordium the cell divisions occur either in the parenchymatous cells of the phelloderm or in the root gap¹⁾ underneath the bud primordium and the differentiation of the conductive tissue follows, finally the latter reach the conductive tissue especially the tracheidal cells in the secondary xylem of the mother tuber, so that the connection between the conductive tissues of the bud and the mother tuber, namely the adventive bud trace are formed.

Pushing aside the cork layer on the root-tuber the growing bud appears at about the surface of the root-tuber. However, the development of the buds of earlier formation soon ceases, while other bud primordia begin to grow, until numerous adventive buds develop,

Fig. 2. Early stages of development of adventive bud. A, showing an adventive bud initial (i) projecting into an intercellular space (s): B, an adventive bud primordium (p) in an intercellular space (s).

1) A provisional denomination for the parenchymatous tissue around the root trace.

but all of them remain as dormant ones around the scars of the lateral roots on the root-tuber in storage. The dormant buds are formed at any region around the root scars, but in no points remote from them. Sometimes we found the adventive buds on the root-tuber where there were no scars of lateral roots, but in such cases generally root scars are found underneath the cork layer. In certain clones the cambial activity of the root-tuber is so large as the root scars are covered by the tissue of the root-tuber.

It is an important problem how the adventive buds are produced on the root-tuber. However, I may mention here in passing that any embryonal cell of a plant can develop into an organ of the plant if it were placed in a suitable situation in which the very organ should develop under the normal condition, so that there is no fundamental differences in the problem how there would develop as adventive bud or a normal bud.

Summary.

1. The adventive buds on the root-tuber of *Ipomoea Batatas* are developed around the scars of the damaged lateral roots. They develop mostly after the root-tuber was harvested, but rarely while the root-tuber is still in the soil. In the latter case the development is related with the damage of the lateral roots or of the root-tuber itself.

2. The initial cells of the adventive buds are derived from the parenchymatous cells of the phelloderm of the root-tuber which were activated by the wound stimulus, probably the wound hormone and auxin. The initial cells project into the intercellular space where they develop as the primordium of the adventive bud. The roll of the humidity on the bud or root formation is to be studied from several standpoints, but I can say here that the wet condition suppresses the formation of the bud primordium while it promotes the development of the root primordium. The airy condition in the intercellular space underneath the cork layer supports the development of the bud primordium while it suppresses the development of the root primordium.

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