

ROOTING STEMS IN TIMOTHY

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INTRODUCTION

In botanical and agricultural literature there are many references to stolons and rootstocks or rhizomes in timothy. However, the statements made and the terms employed are so confused that it is scarcely possible to determine in any case the specific nature of the phenomenon that occurs. It is by no means clear whether rooting stems above or below ground are referred to; neither is it clear to what extent and under what conditions such stems are actually formed. Some writers have concluded that stolons and rootstocks are varietal characteristics, while others indicate that they are very generally found in timothy. No effort has been made by the writers to find the first mention of stolons or rhizomes in the literature on timothy, but apparently they were not mentioned by botanists or agronomists prior to the time of Linnaeus. In the literature of the nineteenth century, however, there are many references, principally to what are termed stolons; but no detailed information is given regarding them, and consequently there is a very general lack of knowledge of just what they really are, or as a matter of fact that they actually exist.

In connection with their timothy breeding investigations, the writers have had the opportunity to study the timothy plant closely, and they have devoted some attention to the rooting stems, which it sometimes produces. The results of these studies it is hoped will clear up the subject somewhat. Most of the data upon which this paper is based were obtained at the Timothy Breeding Station, which is conducted cooperatively by the United States Department of Agriculture and the Ohio Agricultural Experiment Station, at Elyria, Ohio.

TWO KINDS OF UNDERGROUND ROOTING STEMS

In June, 1918, some timothy plants were found growing in a field where timothy stubble had been plowed under the previous fall. These plants on casual observation had the appearance of plants which had grown from seed, but a close examination disclosed the fact that many of them were attached by underground stems to the stubble of the old plants that were turned under. The finding of these underground stems led to further search for plants possessing them and to critical studies regarding their formation. Abundant material was available at the station in the fall of 1918 and in the summer and fall of 1919 in

fields where timothy stubble and plants had been plowed under at different times of the year.

From their investigations the writers found that underground rooting stems in timothy are of at least two kinds and that each develops in a different way. One type of underground stem is that illustrated in Plate 39, A. This type develops frequently when timothy stubble or plants are plowed under in the summer or early fall. It is the normal thing in timothy for the bud that forms the new shoot to develop from a node below one of the enlarged internodes at the base of an old culm. This is the way the timothy plant reproduces itself vegetatively. During the early growth of the shoot the nodes from which the leaves arise are close together. When the shoot grows in length to form a culm with a spike, only about six of the upper internodes elongate. The total length of the 10 to 20 unelongated internodes at the base of the culm ordinarily does not exceed 0.4 inch. Sometimes, however, it is somewhat longer. From the basal nodes, the root system of the new plant is produced.

While the foregoing is what takes place normally, the development of the new shoots may be modified appreciably by external conditions. When timothy stubble or plants that have passed the seedling stage are plowed under, or are similarly covered with soil, buds that make the new shoots start development in the normal way, usually only one bud on a stem. But the young shoot, instead of rooting where it is formed, almost immediately adjacent the mother plant, grows toward the light. In doing so the internodes at or near the base of the new shoot, sometimes only one, usually two or more, elongate, thus pushing it up to the surface in a nearly vertical direction. In many cases small fibrous roots develop from the nodes between these elongated basal internodes. It is in this way that underground stems of rootstock-like appearance are formed. The length of the stem produced by the elongation of the basal internodes and the number of internodes involved depend to a very large extent on the depth to which the old culms are covered with soil. Some have been found having eight internodes, and some with a total length of 5.3 inches. Ordinarily these stems do not extend entirely up to the surface of the soil. An occasional shoot has been observed with its crown 3 inches below the surface, although the crowns are usually much nearer the surface than this. When produced under normal conditions, the crown of the young shoot is at the surface of the soil. The varying depth at which the crowns of the shoots attached to underground stems occur may be influenced by the extent of the leaf growth while it is still beneath the surface. The elongation of the basal internodes, together with the growth that takes place in the leaves, brings the tips of the leaves to the surface. The shoots with the greatest leaf development probably reach the surface with the least elongation of the basal internodes, other conditions being equal. This may explain

why some shoots have their crowns rather beneath the surface than others, even though the buds from which they were produced were covered to the same depth with soil.

Root systems develop from the crown of all timothy shoots having underground stems, and each shoot is soon capable of continuing its growth independently of the mother plant. On a typical plant, selected in November, 1919, from a field in which timothy had been plowed under one year previously, the underground stem connecting the new plant with the parent plant was partly decayed and disintegrated, showing that the plant no longer had any vital connection with the stem from which it originated.

Underground stems of the same type can be induced by placing soil to a sufficient depth about the base of a growing timothy plant. An underground stem which has developed in this way is shown in Plate 39, B. The plant illustrated originated from a seed sown in the spring of 1919. In the following summer soil was placed about the plant to the point indicated by x to the right of the figure. The shoot on the left grew from a bud at the base of a culm of the parent plant. The underground stem that attached the new shoot to the mother plant was 1 inch long and was composed of a single elongated internode. The crown of the shoot was $\frac{1}{2}$ inch below the surface of the soil which surrounded it.

The second type of underground stem is found where timothy plants with growing culms are covered with soil, as by plowing. Buds that sometimes form on the culms of these plants frequently develop into shoots and ultimately into independent plants, and the culms themselves become underground rooting stems. This type is illustrated in Plate 40, A. That the stem a had developed as a culm before it was plowed under is clearly shown by the lower elongated internode, which is enlarged in diameter and which forms what is commonly, but erroneously, termed a bulb. Further evidence that this stem had already developed as an ordinary culm before it was plowed under is found in the dried and partly disintegrated leaf at the second node above the enlarged basal internode. This leaf could hardly have grown to a length of several inches beneath the surface of the soil. In the plant illustrated in Plate 40, A, it was impossible to determine whether the shoot b , growing at the end of the stem, originated from the terminal bud of the culm or from a bud at one of the nodes farther back. It will be noted, however, that there is a secondary underground stem c arising from the second node above the enlarged basal internode. This is of the type shown in Plate 39. It is rarely that secondary shoots develop at nodes between the elongated internodes of timothy culms growing under ordinary conditions, but when the culms are covered with soil this frequently occurs. A rooting stem such as is shown in Plate 39 and in Plate 40, A, c , might have developed in connection with shoot b in Plate 40, A, had the culm a from which it arises been covered to a sufficient depth with soil.

repeated in
numerous
ways

A careful examination of the scattering timothy plants that appear in a field where a timothy sod has been plowed under leads to the conclusion that many if not most of them have not come from seed directly but have been produced vegetatively from the buried stubble or culms. This fact is important agronomically, especially when it is desired to grow pure strains of timothy for seed on the sod of a former timothy crop.

So far as the writers have been able to find, these two types of underground stems, both rooting or at least both capable of producing roots, are the only types of underground stems produced in timothy.

ABOVE-GROUND ROOTING STEMS

Rooting stems sometimes develop above ground, but they have rarely been observed at the Timothy Breeding Station. They are apparently formed when weak or decumbent stems come in contact with the soil. Such a stem is shown in Plate 40, B.

Regarding above-ground rooting stems, Witte¹ says (in translation):

However, in a few cases of dwarf varieties I have noticed that the tufts were less firm, which in turn is due to the fact that the shoots grow out from the axils of the leaves situated higher up on the culm, as, for instance, from the second or third internode above the swollen one. Because in the case of certain varieties at least the lower part of the culm rests on the ground, these shoots easily take root, and in this way we get, as it were, a system of surface runners.

Since the rooting stems that form above ground are apparently but incidentally associated with a decumbent habit of growth, it is very doubtful if they should be regarded as a varietal or strain characteristic. Witte, however, has so regarded them. Ascherson and Graebner² have named and described a variety *stoloniferum*, but from their description it is not clear whether their variety includes plants with rooting stems above or below ground, or both. European literature contains so many references to rooting stems in timothy that it is probable there may be forms in Europe which are not found or are at least are not common in this country. On page 36 of his "Om Timotejen,"¹ Witte figures a very spreading, short-culmed plant which closely resembles one or more of the forms regarded by some botanists as distinct species of *Phleum*, which are characterized in general by a decumbent, spreading habit of growth. The influence of these species or forms on timothy may explain why above-ground rooting stems are mentioned so frequently by European botanists and agriculturists. It is quite evident to the writers that underground stems are in no sense a varietal characteristic, since they can be induced without difficulty.

¹ WITTE, Hernfrid. OM TIMOTEJEN, DESS HISTORIA, ODLING OCH FORMRIKEDOM SAMT OM FÖRÅDLINGSARBETENA MED DETTA VALLGRÄS PÅ SVALÖF. In Sveriges Utsädesför. Tidskr., Årgang 25, Häfte 1, p. 23-44; Häfte 4, p. 143-182; Häfte 5, p. 199-230, 24 fig. 1915. Résumé in German, p. 222-230. Bibliographical footnotes.

² ASCHERSON, Paul, and GRAEBNER, Paul. SYNOPSIS DER MITTELEUROPAÏSCHEN FLORA. Bd. 2, Abt. 1. p. 143. Leipzig. 1898-1902.

NAMES NEEDED FOR DIFFERENT TYPES OF ROOTING STEMS

The question arises as to what name should be applied to rooting stems in timothy. Stems produced above ground are runners or stolons, according to a commonly accepted definition of these terms. However, the examples given in connection with the published definitions are by no means typical of the phenomenon that occurs in timothy. As for the underground rooting stems, those of the first type discussed in this paper are not essentially different from those found for example in Kentucky bluegrass and red fescue, except that they do not develop normally but are induced by unusual conditions. These stems are formed by the elongation of one or more of the lower internodes of the shoots which normally remain unelongated. The elongation of the internodes is for the purpose of placing the new shoots in a more favorable place for growth and development. This might be said to be the function of all underground stems, except possibly tubers, corms, and the like. But true rhizomes, by which are meant underground stems that root at the nodes and produce stems or leaves progressively, have in addition to this another definite function, that of reproduction. It would appear desirable, therefore, to designate by some specific name the underground rooting stems of timothy and other grasses that develop by the elongation of the basal internodes only under unusual conditions and for the purpose of placing the new shoot in a more advantageous location. Mr. C. V. Piper has suggested for such an organ the name "topothete," a Greek word from *topos*, a place or location, and *thetu*, meaning to place. It is evident from a study of the various terms applied to rooting stems and the definitions of these terms that those who formulated them did not appreciate sufficiently the fact that there are at least four distinct types of rooting stems produced by grasses and other plants, two kinds above ground and two kinds underground. Since the existing terms do not meet the needs of the case, the following names are proposed with the hope that they will be given favorable consideration.

DETERMINATE RHIZOME.—An underground stem which is disposed to root at the nodes and from which a single aerial shoot or tuft of shoots is produced; example, Kentucky bluegrass (*Poa pratensis* L.).

INDETERMINATE RHIZOME.—An underground stem, thickened or otherwise, which roots at the nodes and produces aerial shoots progressively; example, quack grass (*Agropyron repens* L.).

DETERMINATE STOLON.—An above-ground stem which roots at the nodes but does not produce aerial shoots progressively. Under this is included lax culms that have come in contact with the soil and have rooted at the nodes; examples, *Paspalum dilatatum* L. and crab grass (*Syntherisma sanguinalis* L.). This type of rooting stem is common in red top (*Agrostis alba* L.) and other species of *Agrostis*. These grasses, however, also have indeterminate stolons.

INDETERMINATE STOLON.—An above-ground stem which roots at the nodes and from which shoots are produced progressively; examples, Bermuda grass (*Cynodon dactylon* L.) and Rhodes grass (*Chloris gayana* L.).

It is quite probable that special terms may be needed where it appears desirable to make finer distinctions than are indicated above. However, it is thought that all of the rooting stems, especially those produced by grasses, can logically be designated by the general terms herein proposed. It is deemed advisable to discontinue the use of the term "rootstock," since this term is misleading and has been used by horticulturists in the sense of propagating stock. There appears to be no serious objections to the use of the word "runner" as a synonym of stolon, although it has been used in a more specific sense, as in the case of the strawberry.

SUMMARY

The references in literature to rooting stems in timothy fail to give a description of their nature or functions.

Investigations disclose two quite distinct types of underground rooting stems.

One type develops when the shoot that produces the new plant is covered with soil early in its growth. Some of the unelongated internodes connecting the shoot with the parent plant elongate, thereby pushing the shoot to the surface of the soil. Roots grow from the nodes between the elongated internodes.

A second type of underground rooting stem is produced when timothy plants with growing culms are covered with soil. Buds that sometimes form on the culms of these plants frequently develop into shoots and ultimately into independent plants. The culms then become underground rooting stems.

Many, if not most, of the scattering timothy plants that appear in a field where a timothy sod has been plowed under are produced vegetatively from buried stubbles or culms.

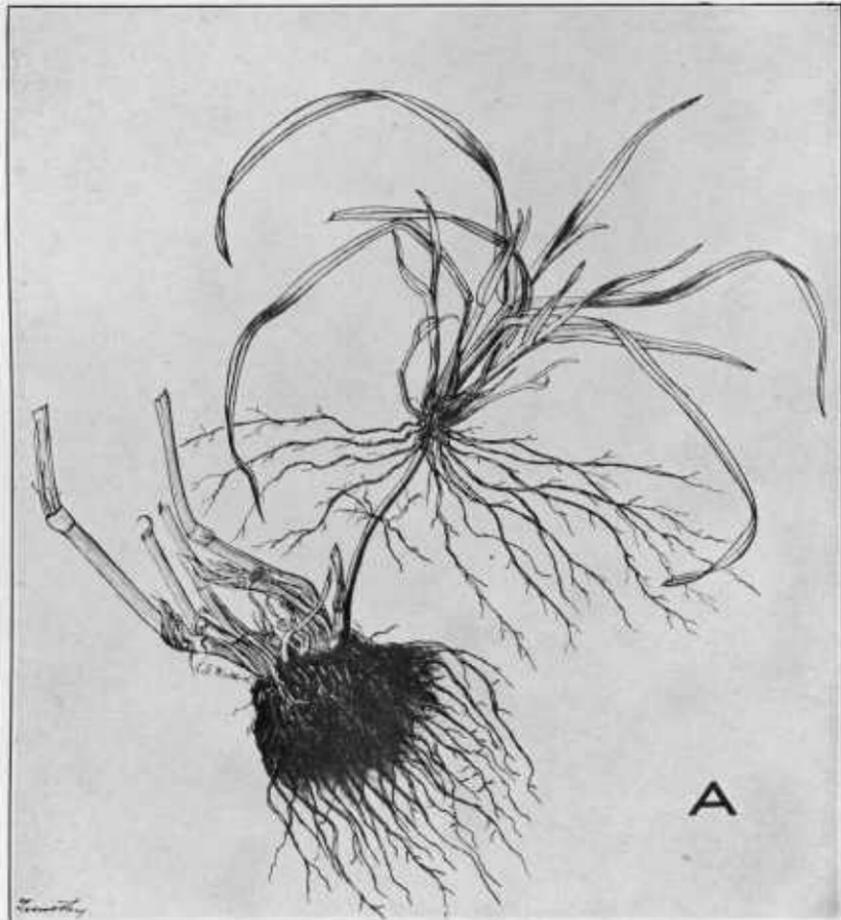
Above-ground rooting stems in timothy are not common in this country. Some botanists have regarded them as a varietal characteristic. It is very doubtful if they should be so regarded. Apparently they are formed most commonly when weak or decumbent stems come in contact with the soil.

Determinate and indeterminate rhizomes and determinate and indeterminate stolons are terms suggested to cover in a general way the types of rooting stems that are found especially in grasses.

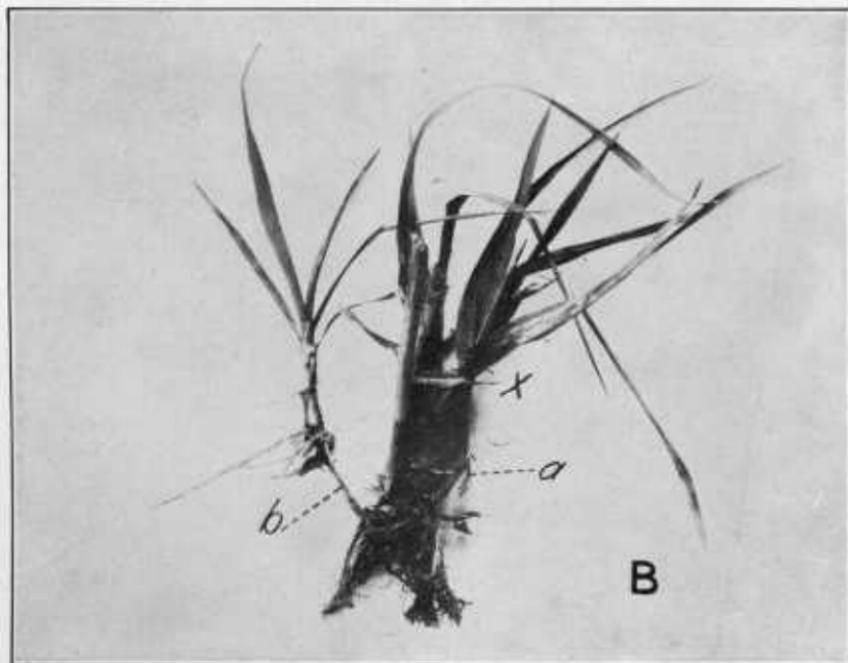
PLATE 39

A.—A young timothy plant produced from a bud on a matured culm plowed under. It was pushed to the surface by a rooting stem formed by the elongation of two of its basal internodes.

B.—A rooting stem *b* induced by covering the parent plant *a* with soil to the point *x*.



A



B

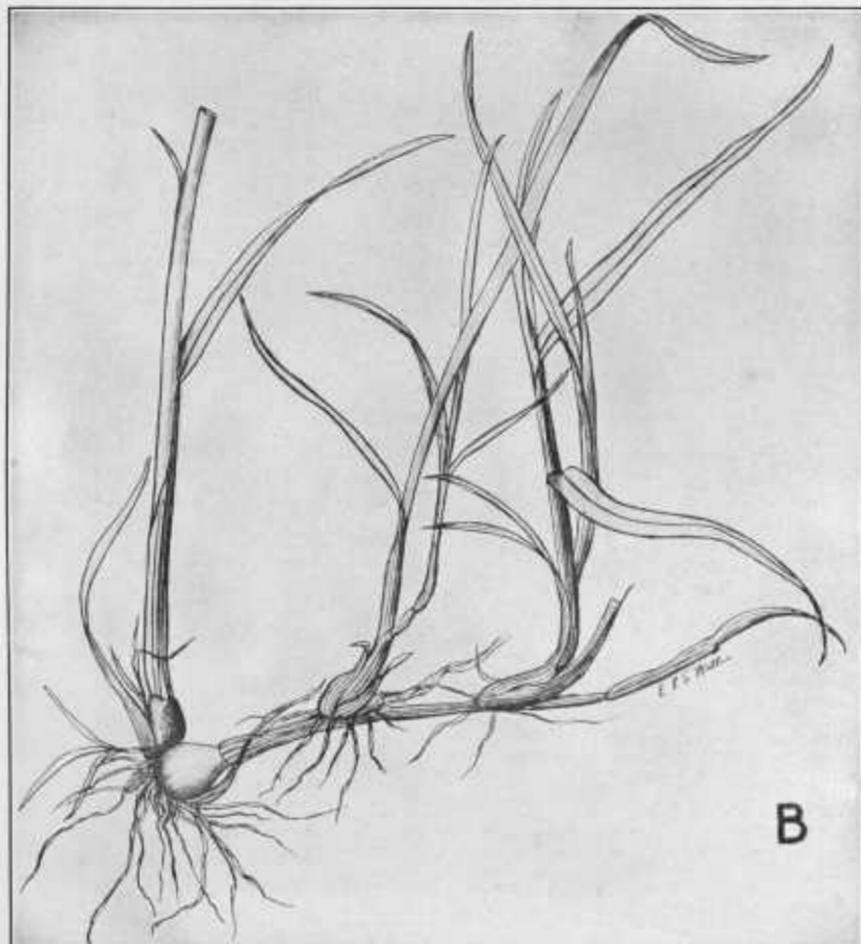
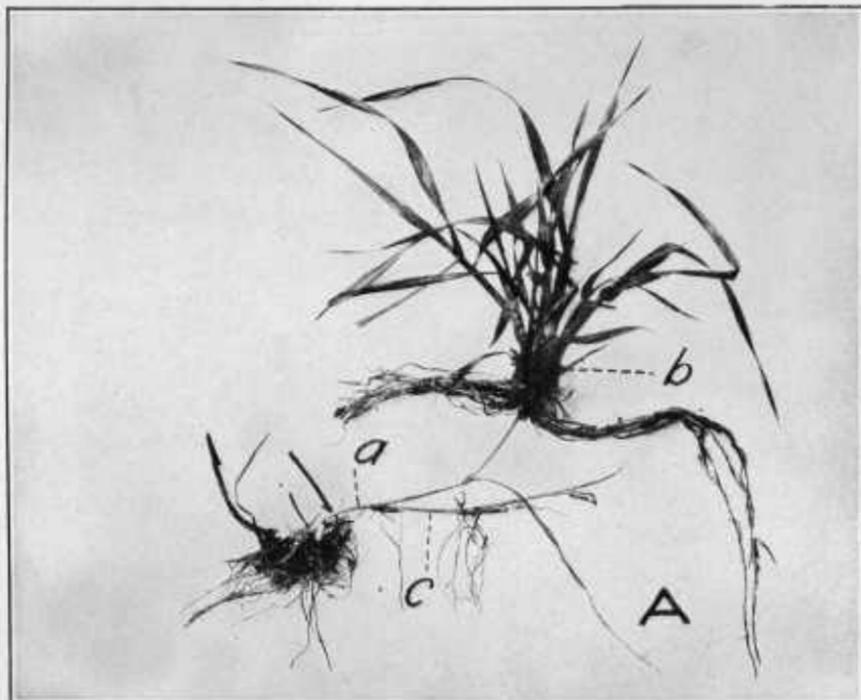


PLATE 40

A.—Timothy plants arising from a true culm that was plowed under. Note the roots at the node *a*.

B.—A decumbent culm of timothy functioning as a stolen (after Witte).