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A NEW METHOD FOR THE SIMULTANEOUS PRESERVATION OF PROFILES AND ROOT SYSTEMS

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Description of profiles has been carried out for many years, but there has remained the difficulty that it is impossible to check the data afterwards by using material collected from these profiles. Since this is often desirable, people have tried to preserve profiles. Preservation, however, is only of value, if the characteristics of the profiles are not altered by the preserving method and if the preserved profiles take up as little room as possible and remain usable for an unlimited length of time. Several authors have tried to meet these requirements. Here we will only mention those two methods which give, in our opinion, the most satisfactory results.

Voigt [7]) described in 1936 a method with which he had obtained good results. In this method a kind of resin (Zaponlack) is applied to the exposed face of a profile in order to fix the soil particles near the surface. After the resin has dried up, the preserved soil film can be removed by hand. This method has been used in the Netherlands during the recent years by Tanis with considerable success [5])[6]). Instead of Voigt's resin solution Tanis made use of a solution of cellulose, which is probably an improvement. This cellulose solution is manufactured by a Dutch factory; its exact composition and concentration are unknown. The solution has a high grade of viscosity, which makes it often necessary to dilute it before application. A mixture of liquids to be used for dilution of the cellulose solution is also obtainable from the same factory.

In 1945 the American investigators Berger and Muckenhirn gave a description of another method [1]). Here use is made of a solution of an artificial resin (vinylite, grade VYHH) in acetone or in methylisobutylketone. We used this method in 1948 [4]).

Preserved profiles nearly 7 years old are still present in a good condition in our laboratory.

Both of these methods have their advantages and drawbacks. The method of Voigt is more simple than that of Berger and Muckenhirn and may give better results with regard to the structure of the soil. On the other hand, in using Voigt's method one is more dependent upon the weather conditions. Rainy weather hampers the preserving effect of the cellulose solution. In general, its applicability is limited, in case of moist profiles, owing to the fact that the penetration of the cellulose solution is reduced in rate by the soil water. Finally it may be a disadvantage, that it is always necessary to visit the place of collection twice, at intervals of at least 10 hours. This is due to the fact, that the preserved soil film can only be removed from the profile when the cellulose solution is dried up completely. Hence this method is rather laborious and expensive. This trouble is of course not so important in the case of mass production of preserved profiles.

When the agricultural value of the profiles to be preserved is to be demonstrated it is important to show simultaneously data concerning the chemical composition of the various layers of the soil, as well as data concerning the moisture conditions.

Usually the yield of a crop may be a measure of the effectiveness of the profile conditions but it is difficult to draw conclusions about the value of the various soil layers without some preservation of plant material. Indications of this are given by the root development. Hence we have developed a method by which the preservation of profiles and of the roots of crops growing on these profiles can be accomplished simultaneously. Kullmann [3]) recently described a method, which gives, however, rather unsatisfactory results. In this communication a description is given of our method.

We started by preserving profiles by the method of Voigt, as modified by Tanis. This led, however, to the difficulties mentioned above. Consequently the method was modified. Initially a partial combination with the method of Berger and Muckenhirn was achieved by using the iron frame of these authors. With this frame monoliths can be taken from the exposed face of a profile. The dimensions of the frame were, in our case, 100 × 25 × 5 cm (Fig. 1) but these dimensions may be varied.

After having obtained one monolith another was taken from the same wall for root investigation by means of a pin-board (Fig. 2). This method is regularly applied at our Station and has been described by Goedewaagen in 1948 [2]). The root system of the crop growing upon the soil surface of the monolith can be uncovered by washing away the soil. The pin-board generally used has a height of about 1 meter, a width of 30 cm and pins of length about 7 cm disposed at distances of about 5 cm. The pins ensure that the morphological structure of the root system remains intact during the washing.

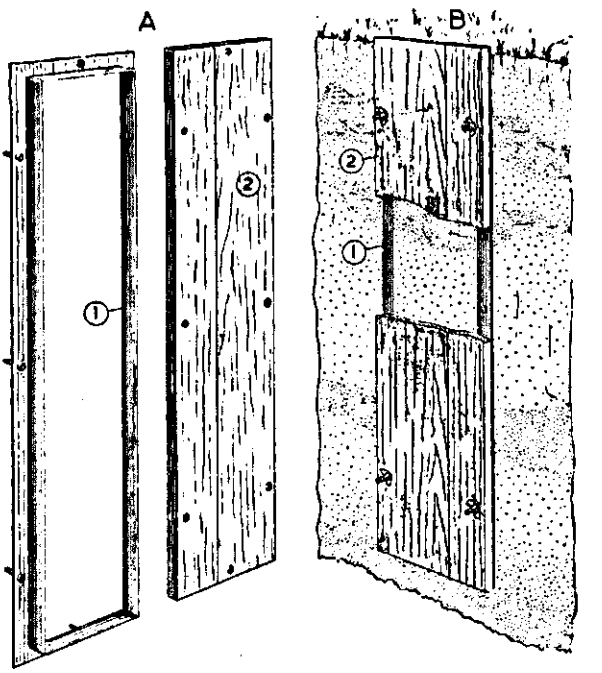

Fig. 1. A. Iron frame (1) with board (2). In the brim of the iron frame the screws are visible with which the board is fixed on the iron frame. B. The iron frame is forced into the soil. On the part, where the board is omitted the brim of the iron frame is visible.

The monoliths in the iron frames, assigned for preservation, are transported to the laboratory for treatment with the cellulose solution. The transportation must be done carefully in order to avoid cracking. It may be possible to preserve several soil films from one monolith in its iron frame. Another advantage of the use

of the iron frame is a greater independence of the weather conditions, because the application of the cellulose solution can be postponed till the return to the laboratory. The preservation of even wet soils is possible in the laboratory by waiting until they are dried to the point, when the solution of cellulose can penetrate into the pores.

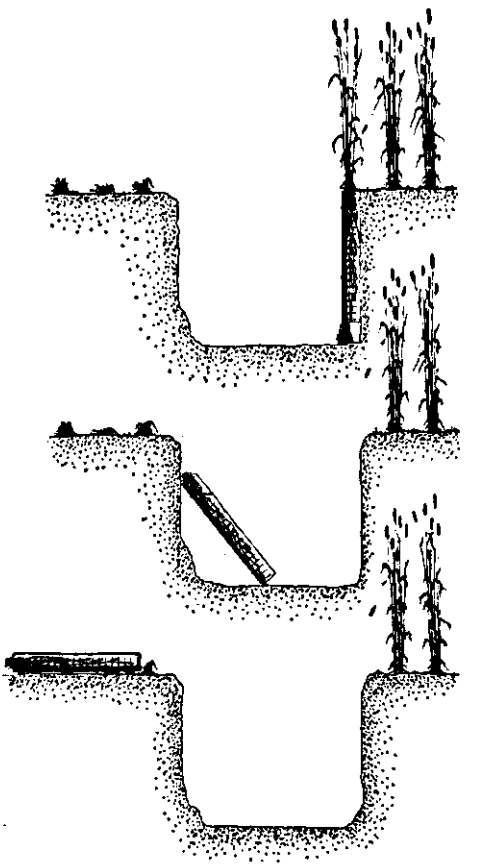

Fig. 2. Scheme of the sampling with a pin-board on behalf of root investigation.

The soil from the monolith on the pin-board is washed away, leaving the root system lying between the pins upon a sheet of black plastic, which is pushed between the pins before the soil sample is taken.

After a little investigation it was shown that the method, described above, can often be simplified by taking one monolith only

on the pin-board. This monolith can be used both for the preservation of a profile and also for uncovering the root system, provided the thickness of the monolith exceeds the length of the pins by about 4 cm (Fig. 3). The advantages are evident. By taking only one monolith for both treatments the preserved profile and the root system are derived from closely adjacent parts of the soil. Consequently the root development on the pin-boards generally shows a close response to the properties of the soil, as indicated by the preserved soil film.

This simple method can only be applied if the pins do not cause the soil to split. Cracking of the soil sample may occur for instance where hardpans are present. In such cases only is the use of the iron frame preferable.

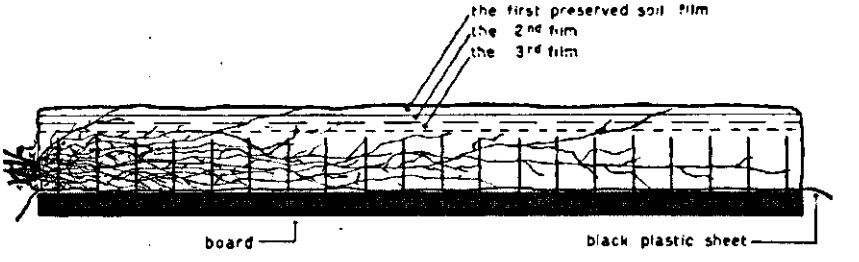

Fig. 3. Scheme for taking one or more soil films and for fixing the root system by means of a pin-board sample.

The actual preservation of a profile on a pin-board in the laboratory is carried out in the following way. The monolith is placed in a slightly tilted position. The surface of the soil outside the pins is smoothed carefully by means of a sharp knife. It may be necessary to sharpen the knife repeatedly during this process. Next the solution of cellulose is poured over the smoothed surface. (Fig. 4), after which the profile is left untouched until the cellulose solution is dried to a firm but flexible film. This can then be removed from the monolith by pulling it away. We start pulling at the bottom of the profile in order to avoid the fixation of loosening soil particles in the wrong place (Fig. 5). Profiles taken on grassland should preferably be cut free in the upper 10 cm since the top layer often contains so many roots the strength of which exceeds that of the cellulose film. Because of the smoothing effect of the knife nothing is visible of the natural structure of the soil in the upper

part of the film. It can, however, be made visible later by tapping the inner side of the prostrate film with a hard brush, so that its natural appearance is again developed.

The thickness of a cellulose film in sandy soils is on the average only a few millimeters.

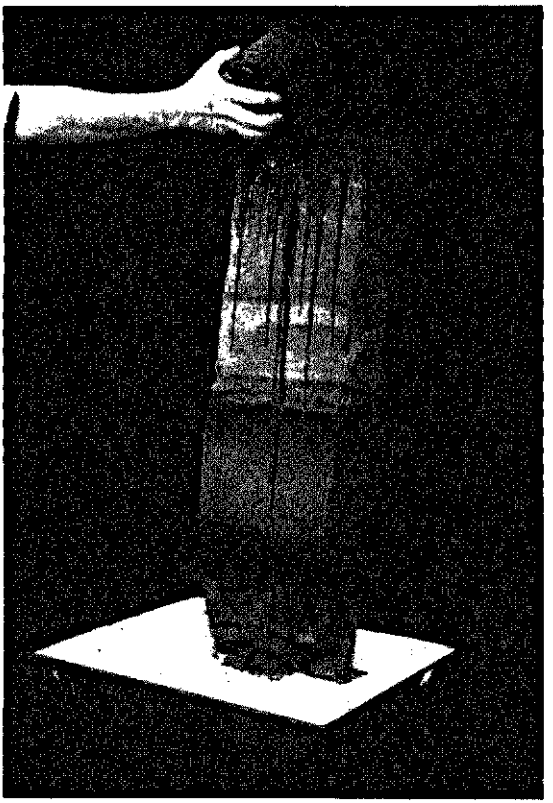

Fig. 4. The cellulose solution is poured over the face of a soil sample on a pin-board.

In some cases preservation of a number of films from one profile may be required. This can be made possible in the following way. After having removed the cellulose film the soil of the monolith is smoothed again and then the whole process may be repeated in the way described above, several times, even after the tops of the pins have become visible (Fig. 3).

When the required number of profiles has been preserved, the

remainder of the soil sample is washed away by means of a stream of water. For this purpose the board with the sample is laid in a wooden box partially filled with water. During the washing the root system drops to the board, from which it can be removed by lifting it up by means of the black plastic sheet lying underneath. Plastic and roots are then dried together.

Fig. 5. The soil film is removed from the soil sample.

If the monolith is obtained by means of the iron frame, it can be treated with cellulose in a similar way. The soil in the frame is smoothed flush with the cutting edges of the frame and then the solution of cellulose is poured over the profile. In some cases several profiles can be preserved from one monolith. This can be done by first loosening the board at the back of the frame. A strip of hard-

board fitting exactly in the frame is then passed into the space between the board and the soil. By fixing the original board again with the screws the soil is pushed upwards into the frame to the thickness of the hardboard.

From the above it will be clear that in this case another sample must be taken by means of a pin-board for the preservation of the roots.

It is convenient to fix the profile film upon a background of hardboard or plywood next to the dried root system. The profile is fixed upon the board with the same cellulose solution, as is used for its preservation, in such a way that the upper side of this film is stuck onto the board. Later on a diluted solution of cellulose is sprayed with a vaporizer upon the front of the film in order to fix the soil particles.

For the fixation of the plastic sheet bearing the roots on the board we use a kind of glue, called Saba 810E. Other kinds of glue may answer quite as well, provided they are not dissolved in a liquid which affects the plastic sheet. Acetone or ketones are not suitable since they cause an irreversible wrinkling of the plastic. Moreover the glue must dry colourless.

The glue is painted upon the board, the plastic sheet with the roots is pressed on the board and finally the roots are stuck on the plastic sheet with the same glue. This glue is mixed then with a small amount of spreading agent since it is applied by means of a vaporizer.

It may be useful to frame the board but it is not strictly necessary. A picture of a complete set is given in Plate I.

The method as given above can be used without difficulty for sandy and light loam soils. It is not applicable to soils having a minute pore volume *i.e.* heavy, sticky clay soils, nor to soils having their pores permanently saturated with water, *i.e.* peaty soils. In these cases the cellulose solution cannot penetrate quickly enough. It appeared, however, that freezing of these profiles in a refrigerator might be helpful. In the frozen state the profile is first moistened by a highly diluted solution of cellulose, after which ample time is given for drying, before an undiluted solution of cellulose is added. As the preserved soil films removed from clay soils are generally thicker than those obtained from sandy soils, it is important to reinforce the cellulose layer by covering the monolith with strips of cloth before the cellulose solution has quite dried. In this manner the cloth is soaked with cellulose, and contributes afterwards to the

Plate I. Root development of grass on a sandy soil with a thin humous layer.

Plate II. Root development of grass on a sticky clay soil.

strength of the preserved film. When the cellulose solution is dried, the monolith is removed from the refrigerator.

These films cannot be removed from the monolith as easily as the sandy ones. It will generally be necessary to cut them free from the monolith when the latter has thawed. Afterwards the appearance of the structure can be improved by means of a pointed knife or pin. A fine cracking usually occurs in these profiles.

It is not possible to obtain the root systems from the heavy clay profiles in the usual way. The removal of this kind of soil by simple washing is either impossible or, in the most favourable cases, can only be performed by the sacrifice of much time.

This difficulty can be avoided by thoroughly drying the whole monolith at a temperature of $\pm$ 105°C and then soaking it in a solution of sodium pyrophosphate. We use solutions of 134 grams sodium pyrophosphate in 50 liters of water. Owing to the action of this solution the soil is usually rapidly peptised. After a couple of hours the soil can be washed easily and the roots can be glued upon board in the usual way (Plate II).

SUMMARY

Several investigators have published methods for the preservation of soil profiles by treating them with definite organic compounds.

In these no data are recorded as to the development of the crop roots in the preserved profiles.

In this article a modified technique is described for preserving soil profiles and their root systems simultaneously.

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