CUTTING AND CROPPING IN ARTIFICIAL MEDIA.

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1. Introduction

With increasing mechanisation in floriculture, vegetable growing and in arboriculture, an artificial substrate to replace normal potting soil would be a welcome improvement for growing a number of crops.
One advantage of such a method is that, starting with the "pot-in-pot" system, repotting can be mechanized, just as planting in soil blocks for vegetable growing. This can be labour saving. Another important point is, that the materials are sterile and homogenous. A very important factor is that export to countries, which forbid import of plants in normal soil, can be reopened.
When the materials are light in weight, transport costs can be kept low.
This growing method has also some drawbacks for example, the water supply of the plants must be very well controlled.
A complete nutrient solution, based on the local water composition has to be given when watering. This may be more expensive.
Since most of the substrates have no buffering capacity a nutrient imbalance can be disastrous.
Till 1971 little had been done in the Netherlands, on the growing in artificial media. We knew that there were some artificial media and in Denmark in 1970 we saw a new one in use, namely rockwool. It seemed to us a very interesting medium, especially for mechanisation of plant growing. In 1971 the research programme was started at Wageningen.

2. Growing media

In alphabetical order a discussion follows of the best known artificial media:

2.1. Baystrat

Under this name "Bayer-Holland" sold a synthetic material, made from polyurethane foam with vertical pores. It is a very light material, in dry condition the weight is about 12-20 grammes per dm^3.
When Baystrat is saturated with water, about 50-70% of the pores are filled with water. That means that the bottom of the substrate is saturated for 100%, while the degree of saturation to the top diminishes rather quickly.
In figure 2 you see the water retention curve for Baystrat. These data are obtained by J. Willumsen from the University of Copenhagen.

Because of the vertical pores the roots reach the bottom of the blocks much sooner than the sides.
It is advisable to put the medium on a flat bottom. Before cutting the substrate has to be watered.
Baystrat is a very soft material, so it is possible to insert every kind of cutting ranging from woody to herbaceous ones.
It is very important that cuttings are not put in deeper than 1-1½ cm. (remember the water retention curve).
The young rooted plants may only be potted when the roots are outside the blocks.
This is very important, since after potting in normal soil, most of the water in the blocks will be sucked out by the soil. That implies also, that the young plants have to be watered more in the first two weeks.
Sideways pressure does not harm the roots, vertical pressure must be avoided, to prevent breaking the roots.
In moist condition the pH of the material will be slightly acid to neutral. The medium is sterile, that means that desinfective measures are superfluous.

2.2. BR-8

This medium comes from the U.S.A. and is made from wood pulp to which an acrylate is added by means of a catalytic process. By polymerization the acrylate is bound to the wood fibres.
During the production process of the blocks, holes will be pressed in. At the same time nutrients are added to the blocks: nitrogen phosphorus, potassium and trace elements. The pH is 6,5 ± 0.2. The buffering capacity of the material is very good. The cations exchange capacity is 75 meq/100 g material, that is about the same as a mixture of torf-vermiculite. It is very firm material and remains so after use. A number of blocks are on the market with different dimensions for imprinted holes. For the Netherlands the material is too expensive.

2.3. Jiffy-7 and Jiffy-9

Fabricated in Norway these media are wellknown in the Netherlands. They are made from young peat-moss.
The blocks are pressed in the form of tablets with a diameter of 4,5 cm and a height of 9 mm. In this condition there is a maximum of 20% moisture. During the swelling process the blocks can take up approx. 60-70 ml water, this means about six times their own weight. After swelling the height is about 5,5 cm. During the production process a number of nutrients are added.
On the market the Jiffy products can be bought with pH = 5.5-5.9 and with pH = 6.0-6.3. The essential difference between Jiffy-7 and Jiffy-9 is that the Jiffy-7 tablets are encircled by a synthetic net, not so by Jiffy-9. This net is composed of polyethylene and polypropylene. The meshwidth is approx. 2 mm, while the threadthickness is about 140 microns. The breaking point is approx. 85 grammes per mesh. When dry, no chemical changes will take place in the net; this process starts very slowly when the pots are in use.
With respect to the plant roots the net is neutral. The plant roots are growing through the meshes in the surrounding soil.

As the roots get thicker the meshes break down.
Jiffy-7 must be encircled by a net because without a net the pots are not stable when wet.
Jiffy-9 has another addition. The peat-moss composition is the same as by Jiffy-7 but there is an addition of a bitumen product. That is why the pot is so firm after swelling that it will not collapse.

2.4. Quicee Sure-Start

This medium is specially made to take cuttings. It is produced by Floralife Inc. Chicago Ill. The medium consists of a phenol-formaldehydefoam compound. In the U.S.A. this medium is for sale in several dimensions.
When using this medium the same rules have to be applied for Baystrat: The medium must be rooted very well throughout the blocks before planting. Also after planting in normal soil you have to water the young plants more in the first two weeks. The medium is sterile.

2.5. Rack-Substrat

Rack-substrat is sold by Hartmann International, Western Germany.
The medium consists of any given foam, organic or anorganic manuring and peat. So it is too variable for research work. This mixture will be pressed to blocks with or without a perforated foil.
The products are on the market in several dimensions. After planting the water supply is very important because the soil in which the young plants are planted sucks the water very quickly out of the substrate.

2.6. Rockwool

The artificial medium "Rockwool" was discovered in 1969 by Bøvre and Knoblauch, from the research station in Hornum, Denmark. Now it is manufactured by the firm Grodania at Hedehusene. The trade name of the medium is "Grodan".
Rockwool is made from a mixture of 60% diabase, 20% limestone and, after adding 20% cokes it is melted at a temperature of ± 1500-2000°C. The molten substance is extruded to threads of 0.05 mm and pressed into sheets weighing 80 kg per m^3. During cooling off, a phenol resin is added when the temperature is about 200°C. After adding the phenol resin, the rockwool can take up water, for the surface tension diminishes. The percentage of pores of the manufactured rockwool is about 96. All the pores have about the same size and this has very important consequences for the water holding capacity.
The next table shows the percentages of water and air in the material with increasing height.
Since it is a sterile medium, desinfective measures are superfluous.
At this moment two kinds of blocks are available: cutting blocks and growing blocks.
The cutting blocks are manufactured on a layer of paper of 30x30 cm, comprising 36 (5x5x5 cm), 64 (3,8x3,8x3,8) or 100 (3x3x3 cm) blocks, depending on the size of the blocks. To simplify handling all the blocks have small holes.

Table 1 - Water- and air management in Rockwool blocks depending on the height of the pot.

Height above water table (cm)	% dry matter	% water	% air	% pores
0	3,8	94	2	96
5	3,8	82	14	96
10	3,8	38	58	96
15	3,8	17	79	96

In figure 3 you see the water retention curve for rockwool. These data are also from the University of Copenhagen.

The growing blocks are of several sizes. At this moment there are blocks of 0,4, 1, 2, 3 and 6 l.
Grodania introduced the so-called "pot-in-pot" system (fig.1), with the following combinations:
3,8 cm. cutting block → 1 l. growing block → 6 l. growing block.
0,4 l. block → 1 or 3 l. growing block.
When we put the blocks on a layer of rockwool and we supply this layer with water and nutrients,it is possible to simplify the entire growing system from beginning to end. It is to be expected that soon the supply of water as well as nutrients can be controlled automatically.
When planting plants raised in rockwool into normal soil or in larger rockwool blocks it is necessary that the plants are rooted very well throughout the blocks.
At first the soil must be kept at field capacity by frequent irrigations
The chemical composition of rockwool is:

S_iO_2	47%	MgO	10%
Al_2O_3	14%	MnO	1%
TiO_2	1%	Na_2O	2%
FeO_3	8%	K_2O	1%
CaO	16%		

In new material the pH is relatively high (>7), (we measured sometimes 9-9.5), but by watering the rockwool before use for some hours the pH decreases rather quickly and by adding some acid it is easy to attain a pH = 6.

3. Results of growing trials

3.1. Rooting cuttings

All the cutting trials had been done under mist propagation. We started in 1971 with the media previously discussed. At first we experienced many complications for most of the media were too wet and we inserted our cuttings too deep.

After putting the blocks upon a wire grid and by cutting to max. 1 cm depth all problems were solved and all the trials were successful. They were successful in so far that it is possible to root plants in all the media but there are differences in growth rate.
We found the best results with Jiffy products and with rockwool. Having enough experience with Jiffy, we continued with rockwool.
One of the most interesting things with rockwool is the "pot-in-pot" system, especially with a view to mechanization and labour saving. In the following trials we only compared rockwool with normal soil.

3.2. The nutrition

I have had a lot of advice from Mr. Steiner, who is working on hydroponics at the CPO in Wageningen.
Nutrient added in grammes per 1000 l. water based on pH = 6.

	destilled water	our well-water
KH_2PO_4	135	134
K_2SO_4	251	154
$MgSO_4.7aq$	497	473
$Ca(NO_3)_2.4aq$	1059	882
KNO_3	292	444
KOH	22,9	---
$H_2SO_4.10N$	---	125 ml.
FeNaKEDTA,5mgFe/ml	400 ml.	400 ml.
$MnSO_4.1aq$	2	2
H_3BO_3	2,7	2,7
$ZnSO_4.7aq$	0,5	0,5
$CuSO_4.5aq$	0,08	0,08
$Na_2MoO_4.2aq$	0,13	0,13

With this nutrient solution nursery stock, flowers and vegetables were cultivated.

3.3. Nursery stock

With mist propagation cuttings in 3,8 cm rockwool blocks as well as in normal soil:
Chamaecyparis lawsoniana "Columnaris",
Forsythia intermedia,
Weigelia florida "Nana variegata",
Buddleia davidii crispa,
Buxus sempervirens,
Euonymus fortunei "Gracilis",
Lonicera ledebourii,
Lonicera nitida "Hohenheimer Findling",
Salix sachalinensis "Sekka",

Symphoricarpus chenaultii,
Cotoneaster salicifolia var. floccosa.

The plants were potted either in 1. rockwool blocks or in 1 l. pots with soil at the moment that the propagated plants were rooted very well throughout the blocks. At that moment there was not any difference between rockwool and soil.
After hardening off, all the plants were put out on sand beds in the open air and cultivated to a marketable size.
Water and fertilizer were given automatically by an electrical moisture sensor. The adjustment is based on measuring the moisture capacity of the sand beds by the apparatus, So every time that it is too dry the apparatus comes in and gives water as well as nutrients.
The growing results were favourable. None of the plants grown in rockwool were inferior to those grown in soil.
Depending on the crop the growing period was 1 or 2 years, exept for the Chamaecyparis plants, which are now 3½ years old and still flourishing.

3.4. Floriculturals

Trials with chrysanthemum, hibiscus and miniature roses proved that it is well possible to grow a number of floriculturals in artificial media.
For the future I am especially thinking of industrial plant growing as can be done for example with chrysanthemum, Saintpaulia, Euonumus Poinsettia, miniature roses and bulb flowers.
After selling, the flowering time is the same as for plants grown in normal soil.
You can give some simple nutrients but it is not necessary.

4. Summary

Trials in 1971-1973 proved that there are good possibilities to cut and to grow a lot of horticultural crops in the artificial media Baystrat, BR-8, Jiffy-7, Jiffy-9, Quickee-Sure-Start, Rack-substrat and rockwool.
Knowledge of the properties of the different materials is essential for obtaining good results.
If planted out into the soil, the propagated plants have to be rooted very well throughout the blocks.
The soil must be at field capacity by regular irrigation during the first weeks after planting. The materials are free of disease, whereas soil desinfection is superfluous. At this moment rockwool is the most interesting medium for it is the only one in which we can make a complete crop, because the other artificial media are only obtainable in blocks of small size.
The composition of the nutrient solution depends on the quality of the available water. In Holland we only can use well-water of good quality, rain water and tap water.
The "pot-in-pot" system can be mechanised and is labour saving.

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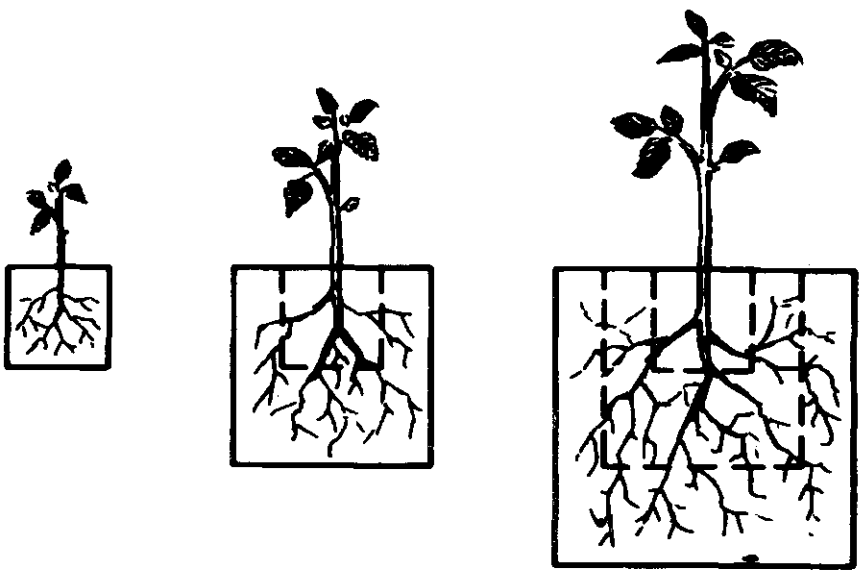

Figure 1 - Grodania "pot-in-pot" system

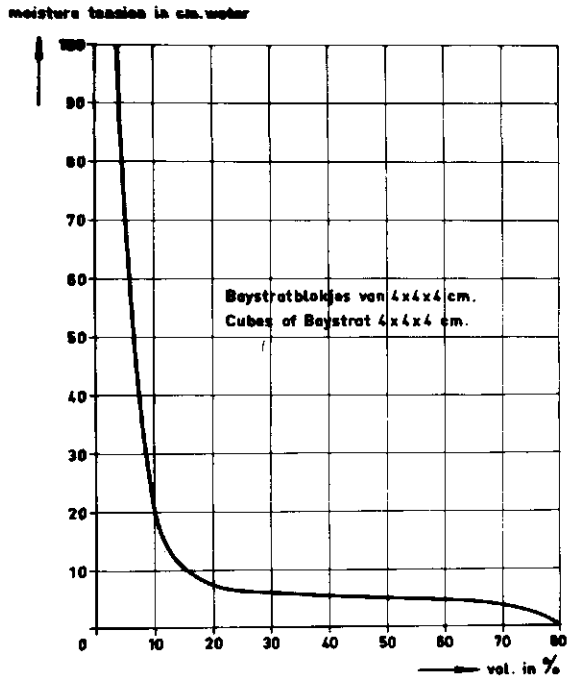

Figure 2 - **Waterretentioncurve for Baystrat.**

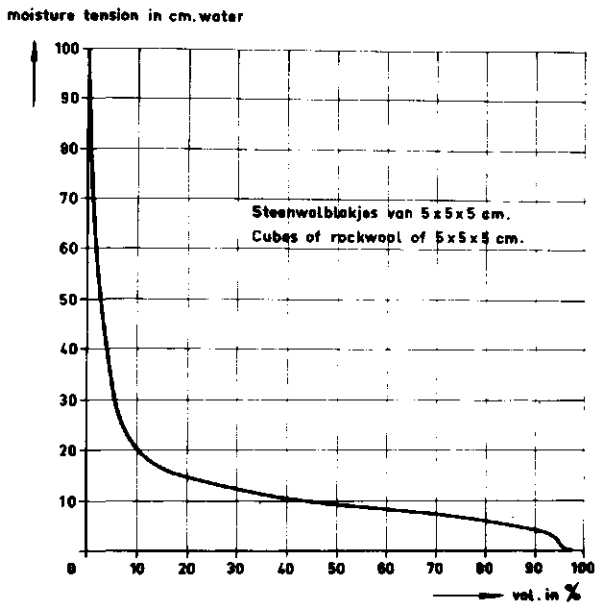

Figure 3 - **Waterretentioncurve for rockwool.**