Concerning the Application of Special Organic Fertilizers with Difficult Afforestations

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Introducing the problem: *The use of mineral fertilizers has been very successful in forestry, i. e., with afforestations on soils with a low content of nutrients (BAULE and FRICKER, 1967; FIEDLER et al., 1972). However, mineral fertilizers are not very popular with highland afforestations, as there is a danger that with excessive fertilization the plants might be damaged when exposed to frost (Fiedler et al., 1973). It is in fact difficult in the case of highland afforestations to find out which amounts of mineral fertilizer should best be applied (GLATZEL, 1976). With low amounts it often happens that the fertilizer gets absorbed by the raw humus or is washed away quickly, thus remaining completely ineffective, whereas too high amounts can, under unfavourable conditions, produce temporary symptoms indicating over-fertilization. Afforestations on virgin soil are also problematical as mineral fertilizers are easily washed out due to the extraordinarily low water retention capacity of such substrates; furthermore, high initial dosages can lead to root etchings.*

*With difficult recultivations such as are necessary on ski-runs above the timberline and recently prepared slopes alongside roads, rivers etc., the use of special organic fertilizers has been very successful in the last few years (INSAM and HASELWANDTER, 1985; NASCHBERGER and KÖCK, 1983). Such fertilizers are advantageous in that they produce a slow and permanent fertilization effect and positively influence the development of roots and root symbionts (mykorrhiza). Hence, it was only logical that such fertilizers should be tested also with regard to their influence on silvicultures. Trials *) were arranged with potted spruces cultivated on two different soil substrates in order to solve basic questions like dosing and plant tolerance, e. g., whereby the effects of organic fertilizers on the growth, root formation, and nutrient balance of the plants were compared with those of mineral fertilizers.*

The results obtained in these trials were quite encouraging. From them, important guidelines can be drawn for fertilization measures to be taken in connection with difficult afforestations.

Method employed

Experimental arrangement:

On two different soil substrates, two different fertilizers were tested as to their effect on spruces, namely BIOSOL, a commercially available organic fertilizer, and MINERAL FERTILIZER, a mineral fertilizer, the suitability of which has been proved in practical application. The following variants were tested:

Trial I

Substrate	**Brown earth/semi-podsol**
K	Untreated control
M	10 g of MINERAL FERTILIZER per container
B 1	7.5 g of BIOSOL per container
B 2	15 g of BIOSOL per container
B 3	30 g of BIOSOL per container
B 4	60 g of BIOSOL per container

Trial II

Substrate	**Virgin soil**
K	Untreated control
M	10 g of MINERAL FERTILIZER per container
B 2	15 g of BIOSOL per container
B 3	30 g of BIOSOL per container

For the tests, two year old spruce seedlings were potted in plastic containers filled with three liters of substrate. Each variant was tested twelve times. The samples were then put into the cold house, where they were arranged completely at random. The fertilizers were applied to the soil surfaces only once immediately after the potting. The samples were then attended to and observed for two vegetation periods.

Soil samples

The soil samples employed in the trials were taken in the Kitzbühler Schieferalpen (slate). The substrate employed in trial I was taken from an alpine pasture situated on the timberline, i. e., at approximately 1 750 m a. s. l. The trees growing in the close surroundings are cembra pines and spruces, and also dwarf-pines in some parts. Rhododendron ferrugineum and Nardus stricta are the species dominating the ground vegetation. The soil type is only moderately compacted brown earth/semi-podsol with a relatively thin humus cover. The samples were taken from the top layer of the mineral soil down to a depth of 15 to 20 cm.

The virgin soil samples employed in trial II consist of slate gravel rich in fine sand, which was taken from a new road construction site at 1 250 m a. s. l. Table 1 lists some analytical values obtained for the sample substrates.

Fertilizers

- BIOSOL: This fertilizer manufactured by the Biochemie Ges. m. b. H. in Kundl, Austria (A-6250), is a granulated substance consisting of dried fungal mycelium (Penicillium chrysogenum), a by-product of the manufacture of antibiotics left over after the extraction of the penicillin contained. The mycelium ist dried at a temperature of 120 to 150 °C for two to three hours; thus it is guaranteed that the product available on the market does not contain any residual penicillin.
- This fertilizer is commonly applied in forestry.

The compositions of the two fertilizers tested as indicated by the manufacturers are given in Table 2.

Table 1: Some analytical data obtained for the substrates

Characteristics	brown earth/ semi-podsol	virgin soil
Soil type (hand-tested)	Loamy sand	Muddy sand
pH in 0.1 m of KCl	4.2	4.6
Total amount of carbon (%) C	3.3	0.19
Total amount of nitrogen (%) N	0.16	0.02
C/N-ratio	21	9.5
Extract of ammonium acetate		
K $mg.kg^{-1}$	19	18
Ca $mg.kg^{-1}$	420	31
Mg $mg.kg^{-1}$	52	7
Extract of hydrochloric acid		
K $mg.kg^{-1}$	62	68
Ca $mg.kg^{-1}$	1 160	1 190
Mg $mg.kg^{-1}$	660	900

Table 2: Nutrient contents of the fertilizers

Nutrient	BIOSOL	MINERAL FERTILIZER
N (%)	6.5 *)	12
P_2O_5 (%)	1.9	12
K_2O (%)	4.8	18
Mg (%)	1.3	0.5 (MgO)
Ca (%)	3.1	11 (CaO)
Fe	212 $mg.kg^{-1}$ DS	0.3 % Fe_2O_3
Mn	14 $mg.kg^{-1}$ DS	1.5 % SiO_2
Cu	12 $mg.kg^{-1}$ DS	13 % SO_4
Zn	55 $mg.kg^{-1}$ DS	
Co	5.3 $mg.kg^{-1}$ DS	as well as B, Mn,
Organic substance (% in the DS)	81.1	trace elements, and residual substances
Water content (%)	5.6	–

*) BIOSOL contains only organically bound nitrogen

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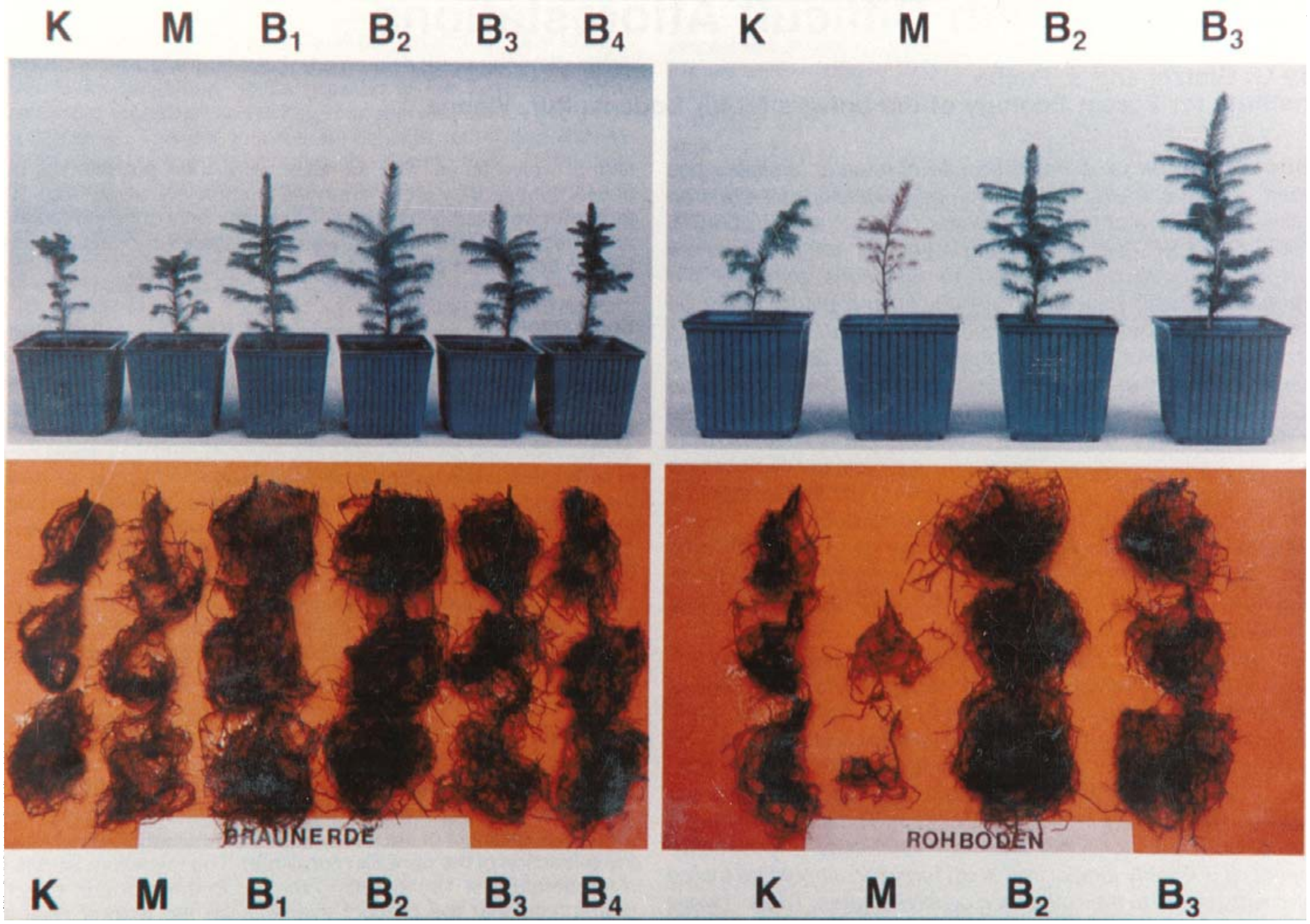
Pictures: Outward appearances of the plants at the end of the testing.



Left: *Trial I (brown earth/semi-podsol).* ***Right:*** *Trial II (virgin soil).*

Above: *Development of sprouts (one plant of each variant, arbitrarily chosen).* ***Below:*** *Root stocks.*

Evaluation

After two vegetation periods the plants were harvested and examined with reference to their growth, root development, and nutritional condition. The statistical evaluation was carried out with the help of analyses of variance as well as multiple range tests according to DUNCAN; the significance of the failure rate was proved by way of the Chi-square test.

Results

Growth

The pictures each show either the outward appearance of one plant arbitrarily chosen from each variant (above) or the root stocks of three plants of each variant (below).

Table 3 lists characteristics of growth observed with the plants on the brown earth/semi-podsol substrate. The graphs in Fig. 1 show the sprout and root masses as well as the lengths of the terminal sprouts. As can be seen, the plants treated with 7.5 and 15 g of BIOSOL per container, respectively, had grown best. These two variants showed better results as to the production of dry matter, increase in length, and root formation than both the untreated controls and the variants treated with mineral fertilizer. In some cases the samples which had received higher amounts of BIOSOL (30 or 60 g per container) responded still better than those treated with mineral fertilizer, however, the differences could no longer be proved statistically.

The growth characteristics obtained with the plants of the virgin soil variant are indicated in Table 4. The sprout and root masses as well as the lengths of the terminal sprouts can be seen from the graphs shown in Fig. 2.

Here, the superiority of the BIOSOL-fertilization is even more clearly visible. Only two of the twelve plants of the mineral fertilizer variant survived the first vegetation period. Obviously, the saline concentrations produced in the soil were too high at the beginning on account of the very low sorptive effect in the substrates. There were no provable differences between the two BIOSOL variants.

Table 3: The characteristics of growth, colour of needles, and development of fine roots of the spruces obtained in trial I (brown earth/semi-podsol)

Characteristics	K	M	B 1	B 2	B 3	B 4
Failures (%)	0	0	0	0	0	0
Lengths of terminal sprouts (mm)	25	45	72	90	52	56
Diameter of root necks (mm)	5.1	6.5	7.5	7.4	6.8	6.5
M of newly developed needles (g)	1.4	2.5	3.7	3.1	2.6	2.4
DM of new sprouting axes (g)	0.45	0.8	1.59	1.37	1.08	0.88
DM of sprouts in total (g)	5	7.4	10.1	8.8	7.3	7
DM of roots (g)	4.8	5.5	7.9	7.7	5.5	4.7
Colour of needles (1 = dark, 5 = light)	3.6	3.2	1.5	1.3	1.7	2.5
Fine root development (1 = very good, 5 = very bad)	3.5	3.5	2.3	1.8	2.8	3.3

Table 4: The characteristics of growth, colour of needles, and development of fine roots of the spruces obtained in trial II (virgin soil)

Characteristics	K	M	B 2	B 3
Failures (%)	0	83	0	0
Lengths of terminal sprouts (mm)	41	23	73	70
Diameter of root necks (mm)	6.1	3.8	7.6	7.6
DM of newly developed needles (g)	1.44	0.37	3.01	2.86
DM of new sprouting axes (g)	0.51	0.15	1.35	0.98
DM of sprouts in total (g)	5.3	1.5	8.2	7.7
DM of roots (g)	4.9	0.93	7.1	6.1
Colour of needles (1 = dark, 5 = light)	2.3	5	1.4	2.3
Fine root development (1 = very good, 5 = very bad)	3.7	4	2.8	2.8

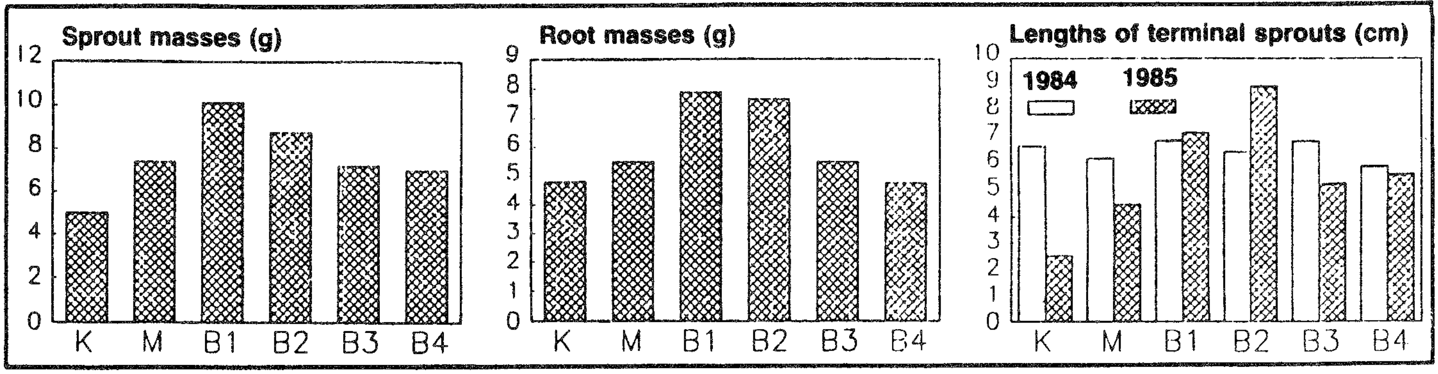


Fig. 1: Sprout and root masses as well as the lengths of the terminal sprouts of trial I (brown earth/semi-podsol)

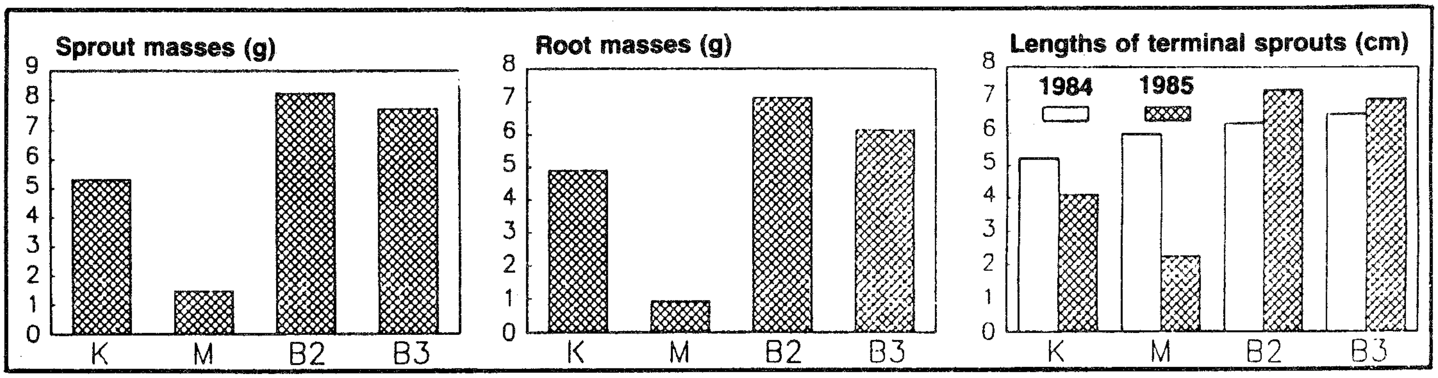


Fig. 2: Sprout and root masses as well as the lengths of the terminal sprouts of trial II (virgin soil)

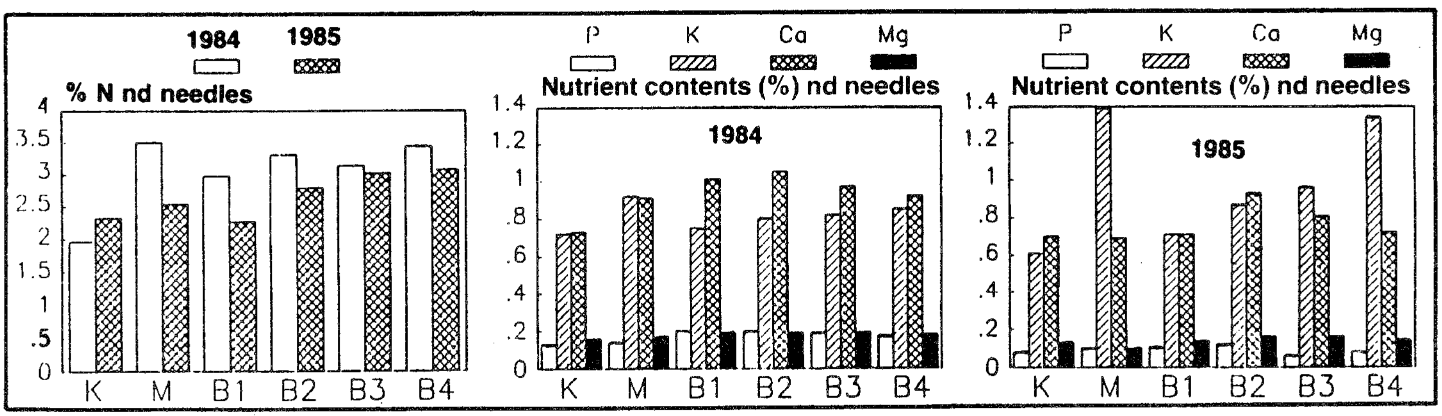


Fig. 3: Nutrient contents of the newly developed (nd) needles obtained at the end of vegetation periods 1984 and 1985 of trial I (brown earth/semi-podsol)

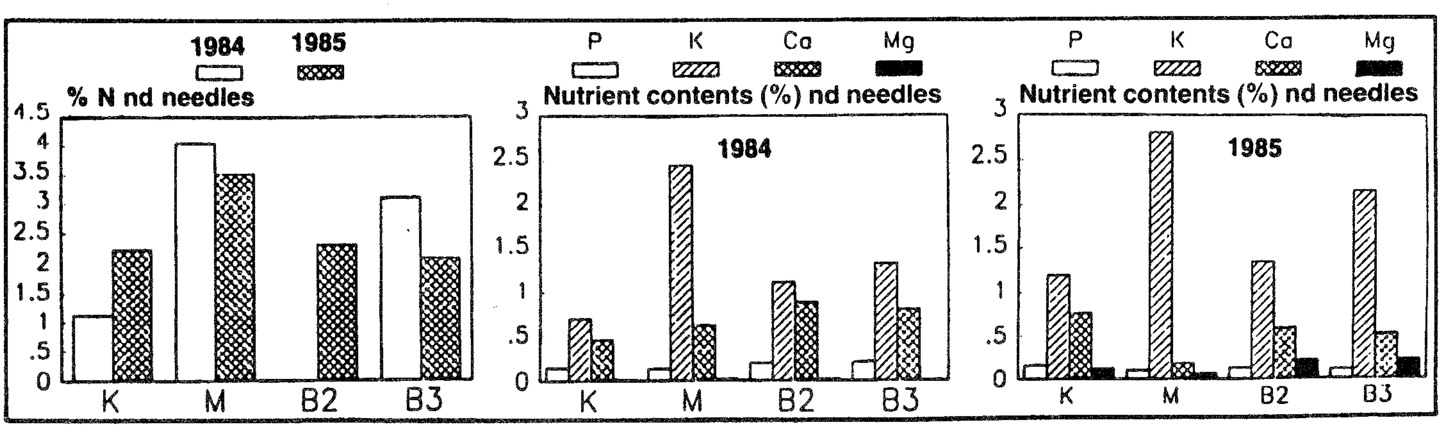


Fig. 4: Nutrient contents of the newly developed (nd) needles obtained at the end of vegetation periods 1984 and 1985 of trial II (virgin soil)

Nutritional condition

Trial I (brown earth/semi-podsol): The graphs in Fig. 3 show the contents of mineral substances in the needles newly developed per vegetation period. All in all it can be said that the nitrogen supply was good, although we must not forget that, due to their delicate needles, plants cultivated in green houses generally show higher N-contents than plants growing in the field, for which, according to Fiedler et al. (1973), nitrogen values of 1.5 to 2 per cent are ideal. The phosphorus supply was rather bad with all variants tested – especially during the second year. The potassium contents in the needles were increased primarily through the application of mineral fertilizer and high dosages of BIOSOL. The strongest increase occurred during the second year. Calcium was taken up in sufficient amounts by all of the plants. As to the magnesium supply, no striking differences can be seen between the individual variants. The nutritional condition was somewhat better with the B 2 and B 3 variants.

Trial II (virgin soil): Here it must be considered that only two plants of the mineral fertilizer variant had survived, so that the mean values of this variant are of little significance (Fig. 4). The nitrogen supply was obviously sufficient with all of the variants; it was particularly high with the mineral fertilizer variant. The potassium contents of this variant were also extremely high. With the BIOSOL variants the potassium supply seems to have been slightly more favourable, perhaps again rather high with the B 3 variant. In the first year, all plants of the trial with virgin soil showed a low Mg supply; in the second year, the Mg contents in the BIOSOL variants were increased to normal, whereas that of the mineral fertilizer variant remained critical. The phosphorus contents were rather bad with all of the variants.

Discussion of the results

Trial I (brown earth/semi-podsol)

As can be seen from the results, the two variants treated with low dosages of BIOSOL were superior not only with regard to the growth of the plants but also with regard to the colour of their needles and the formation of fine roots. The lengths of the terminal sprouts show that the much-feared stress by transplanting, a symptom causing a reduction in annual linear growth, had been prevented through the fertilization. In the first year, no positive effects were produced concerning the growth of the terminal sprouts, as they had been developed from buds which had already been formed before the fertilization. However, the nutritional condition of the needles was improved through the fertilization in the first year, already, so that there were enough reserve substances available for sprouting in the second year. It ist most striking that the mineral fertilizer variant did not produce equally positive results with regard to plant growth, needle colour and fine root development as had been obtained with the BIOSOL variants B 1 and B 2, although the nutrient contents in the needles differed only slightly. This may be due to the better-balanced nutrient supply provided by the organic fertilizer and its possible direct effect on the rhizosphere.

Trial II (virgin soil)

Just as we had expected, the superiority of slow-acting organic fertilizers over easily soluble mineral fertilizers was particularly striking on virgin soil with a low sorptive effect. Here, an amount of 10 g of mineral fertilizer, which was perfectly well tolerated by the plants of the brown earth/semi-podsol trial, caused root etchings, thus leading to the result that most of the plants were stunted. The remaining plants exhibited extremely severe symptoms of growth stress as well as a very ill-balanced nutritional condition in the second year. The colour of the needles (Mg deficiency) as well as the formation of fine roots left much to be desired.

Final conclusions

As was demonstrated in the two trials with potted plants, the special organic fertilizer BIOSOL is well tolerated by spruces if applied to the surface of the soil. It should not be mixed into the soil since it was shown in preliminary tests that if BIOSOL is mixed into the soil before the beginning of winter the plants could be damaged during the winter.

BIOSOL has met our expectations in that its superior characteristics – a slow and permanent nutrient supply and positive effects on the roots – are particularly well brought into effect in virgin soil with a low sorptive capacity. As can be seen from the tests, BIOSOL is a perfectly suitable fertilizer for afforestations in high altitudes and on virgin soil, as it prevents the above-mentioned stress by transplanting and promotes the growth of plants. The problem of what dosages should best be applied with highland afforestations is presently being investigated in a series of field trials. As these trials have been running for only one year now it is still too early for final recommendations to be given, however, it can be taken for granted that the amount of BIOSOL to be applied per plant will in any case be within a range of 80 to 150 g. The fact that higher amounts have to be applied in the field can be explained by the larger soil volume, a slower decomposition rate due to the cool highland climate, and the presence of competitive plants such as dwarf shrubs and grass. On virgin soil, the amount applied per plant within a radius of 20 cm should, for the present, not exceed 100 g. We would appreciate any short information on experiences made with the application of special organic fertilizers in forestry.

Summary

The special organic fertilizer BIOSOL was tested with regard to its effect on potted spruces cultivated on brown earth/semi-podsol and/or virgin soil substrates. The variants compared in the trials also included untreated controls and a mineral fertilizer variant.

It showed that a surface application of BIOSOL is perfectly well tolerated by the plants, which responded with better growth, a deeper green of the needles, the formation of a more complex root system, and a well-balanced nutritional condition. Particularly favourable results were achieved when applying BIOSOL on virgin soils with a low sorptive effect, where easily soluble mineral fertilizers can cause root etchings and are often washed away quickly. According to these results, BIOSOL can be recommended as a fertilizer for afforestations in high altitudes and on virgin soils; the application of BIOSOL is a suitable measure to be taken in order to improve the growth and general health of the plants and to lessen the stress by transplanting. Field trials are being carried out in order to find out which amounts of the fertilizer produce the best results and to observe its influence on plant growth for a longer period.

Literature References

1) BAULE, H. und FRICKER, C. 1967: Die Düngung von Waldbäumen. BLV München, Basel, Wien.
2) FIEDLER, H. J., NEBE W., und HOFFMANN, F., 1973: Forstliche Pflanzenernährung und Düngung. Gustav Fischer Verlag, Stuttgart.
3) GLATZEL, G., 1976: Mineralstoffernährung und Aufkommen von Fichtenkulturen nahe der alpinen Waldgrenze. Cbl. ges. Forstw. 93, Heft 1, 1–23.
4) INSAM, H. und HASELWANDTER, K., 1985: Die Wirkung verschiedener Begrünungsmaßnahmen auf die mikrobielle Biomasse im Boden planierter Schipisten oberhalb der Waldgrenze. Zeitschrift für Vegetationstechnik 8, 23–28.
5) NASCHBERGER, S. und KÖCK, L., 1983: Erfahrungen über die Wirkung von Biosol bei der Begrünung von Schipisten. Zeitschrift für Vegetationstechnik 6, 33–36.