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# FERTILIZATION AND IRRIGATION OF YOUNG NORWAY SPRUCE ON SANDY SOIL

## GØDSKNING OG VANDING AF UNG RØDGRAN PÅ SANDJORD

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## INTRODUCTION

Under Danish climatic conditions the precipitation during the growing season is a minimum factor for Norway spruce (*Holmsgaard* 1955). The heathlands of Jutland have scanty soil-water reserves, and also the supplies of various nutrients are minimal (*Holstener-Jørgensen* 1970). In these localities of sandy soils, effects may be expected of irrigation as well as of fertilization, and any interaction of those factors may be measurable.

The absorption of nitrogen has been registered to be lower in summers of drought than in normal summers (*Wehrmann* 1961). The mineralization of organically fixed nitrogen in the soil is dependent on the soil moisture. Similar observations may be made on other organically fixed nutrients, and, finally, the absorption of nutrients is dependent on the presence of accessible water in the soil.

It is a question, therefore, to what extent the lower increment that can be registered in summers of low precipitation is due to lack of water, to what extent it is due to lack of nutrients, and, finally, to what extent there is an interaction of those two factors.

To elucidate these problems, an experiment comprising irrigation and fertilization of young Norway spruce on heathland in Central Jutland was established in the spring of 1971.

### *The experimental area.*

The experiment is located on heavily podsolized heathland. A 1st generation of 45-year-old mountain pine was underplanted in 1938 with Norway spruce. In 1959 this Norway spruce stand, then 24 years old, was destroyed by fire, and in the spring of 1960 the area was again planted with Norway spruce and Pinus contorta in alternate rows, the Pinus contorta serving as nurse tree, because the area is badly exposed to late frost.

At the time of establishment in April 1971, heather covered all the ground between the trees. As appears from the graphically illustrated mean heights (Fig. 2), there was quite some variation in the height development of the plantation. This is often seen on heath-clad outwashed plains, and it is also typical of stagnant heathland plantations. The trees were marked by a mild stagnation and had short, yellowish needles and short shoots.

### *The experimental arrangement.*

Fig. 1 is a sketch of the experimental arrangement. The plots are square. The gross plots are 30 $\times$ 30 m, whereas the net plots, in which the measurements were taken, are 20 $\times$ 20 m. The treatment codes appear from the text of the figure.

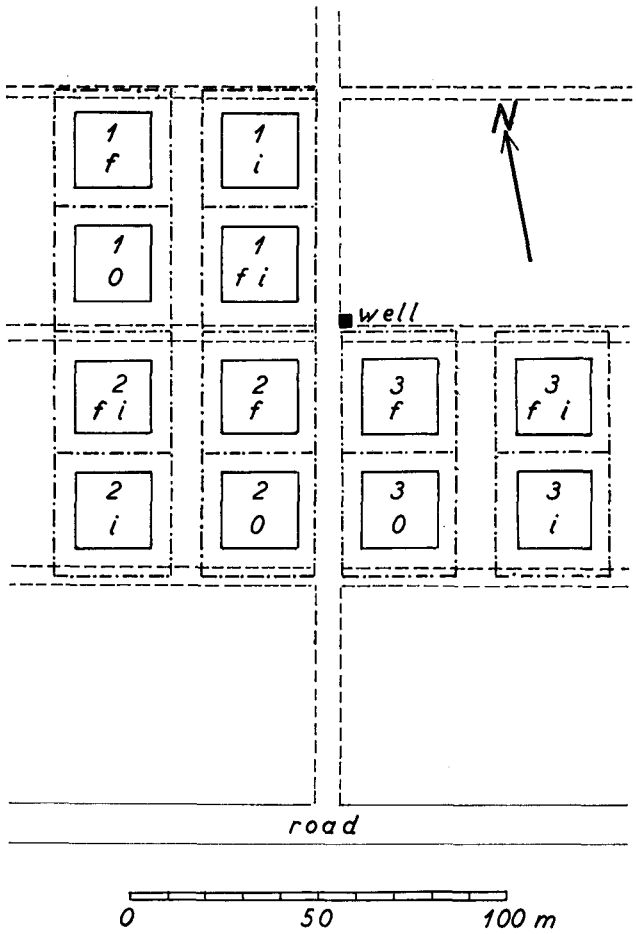


*Fig. 1.* Sketch of the experimental area. i = irrigated; f = fertilized; 0 = not treated; 1 = block designation. For further details, see the text.

*Skitse af forsøgsarealet. i = vandet; f = gødet; 0 = ubehandlet; 1 = blokbetegnelse. Se iøvrigt teksten.*

The *irrigation* is made by a field irrigation system with sprinklers installed in 15 × 12 m rectangles. The water is drawn from a well that is 38 m deep and has a water level 10.2 m below ground level.

The irrigation is regulated by a mean curve for potential evapotranspiration for Denmark (*Aslyng* 1954). This curve has been raised by multiplication by 1.2 in order better to match the actual conditions in "drought years", during which the evaporation is presumably higher than the values of the mean curve. The precipitation is measured at a ranger's house 1600 m south-southeast of the experimental area. The difference between the evapo-

transpiration sum (from 1st April) and the sum of precipitation and irrigation water determines the timing of the irrigation. Irrigation is made when the mentioned difference reaches 50 mm, and the irrigation is chiefly made in the night in order to reduce the loss by evaporation.

The quantities of irrigation water used during the past 3 years appear from Table 1, to which no further comments shall be added.

The *fertilization* has consisted in application of 1500 kg Nitrophoska per hectare in the first year, and each of the following years 248 kg Nitrophoska + 540 kg $Ca(NO_3)_2$ were applied per hectare.

Table 1. Quantities of precipitation and irrigation water registered.
*Tabel 1. Oversigt over nedbørs- og vandingsregnskab.*

| | | | April *April* | May *Maj* | June *Juni* | July *Juli* | August *August* | September *September* | Sum *Sum* |
|---|---|---|---|---|---|---|---|---|---|
| 1971 | precipitation *nedbør* | mm | 29 | 42 | 65 | 78 | 90 | 67 | 371 |
| | irrigation *vanding* | mm | 0 | 103 | 24 | 107 | 0 | 0 | 234 |
| 1972 | precipitation *nedbør* | mm | 104 | 97 | 100 | 105 | 28 | 32 | 466 |
| | irrigation *vanding* | mm | 0 | 0 | 46 | 47 | 0 | 48 | 141 |
| 1973 | precipitation *nedbør* | mm | 65 | 56 | 33 | 53 | 40 | 71 | 318 |
| | irrigation *vanding* | mm | 0 | 0 | 92 | 92 | 47 | 41 | 272 |

*Measurements.*

So far the measurements have consisted only in height measurements. These have been made each year in 4 rows in each net plot. The same trees were measured each time. Therefore the mean values of the height differences constitute the true height increment.

## RESULTS

Mean values of initial heights and true height increments are represented in Fig. 2. Values for plots that have received the same treatment are connected by full-drawn lines. In each of the three years there is a clear relationship between initial heights and height increment. For the individual year the relationship can be described by regression equations with a common regression coefficient but with different levels where the differences in level are the effects of the treatment.

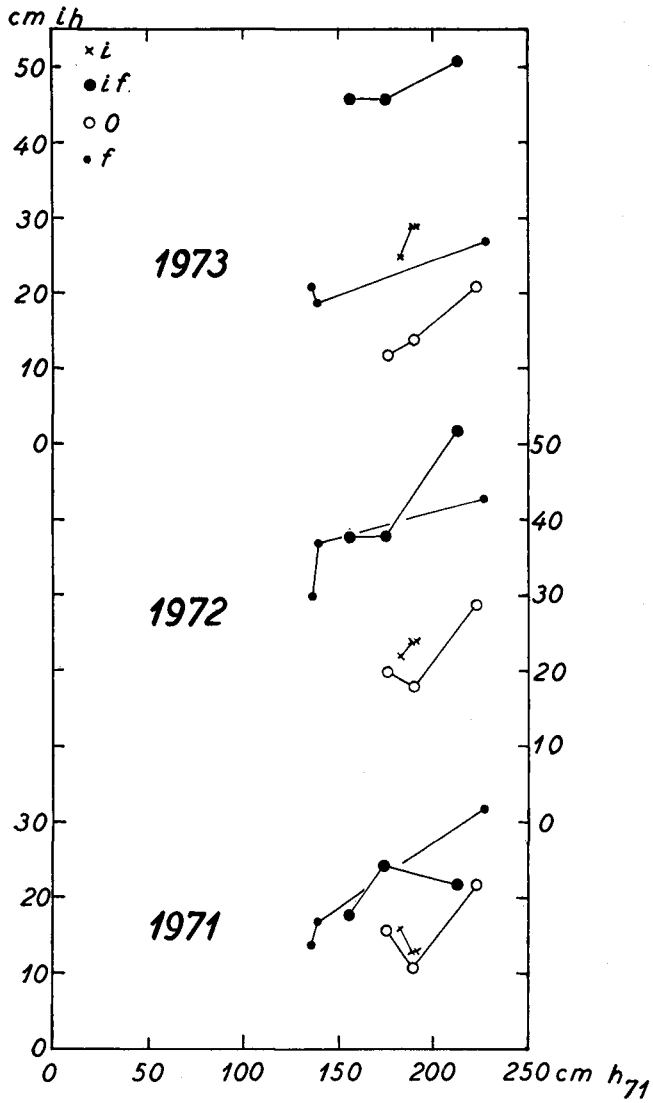


*Fig. 2.* Mean top-shoot lengths (cm $i_h$) superimposed on initial heights ($h_{71}$) in each plot.
i = irrigated; if = irrigated + fertilized; f = fertilized; 0 = not treated.
*Middeltopskudslængder (cm $i_h$) lagt op over starthøjder ($h_{71}$) i de enkelte parceller.*
*i = vandet; if = vandet + gødet; f = gødet; 0 = ubehandlet.*

The material has been subjected to an analysis of covariance, but the details of these calculations will not be reported here. They prove that in each of the years there is a significant covariance between initial heights and height increment, and that, apart from this fact, there are significant effects of treatments. These effects vary from year to year.

A summary of the results is obtained by adjusting all values for covariance. Table 2 shows the mean values of the adjusted height increments together with the appropriate mean errors.

Table 2. Mean-height increments for each treatment after adjustment of the height increments of the individual plots for differences in initial heights. Adjustments by analysis of covariance have been made for each year separately.

*Tabel 2. Middelhøjdetilvækster for de enkelte behandlinger efter korrektion af de enkelte parcellers højdetilvækster for forskelle i starthøjder. Der er gennemført kovariansanalytiske korrektioner for hvert år for sig.*

| | | Not treated *Ubehandlet* | Fertilized *Gødet* | Irrigated *Vandet* | Fertilized + irrigated *Gødet + vandet* | Mean error *Middelfejl* |
|---|---|---|---|---|---|---|
| 1971 | cm | 14.7 | 23.0 | 13.3 | 21.3 | ± 0.94 |
| | % | 100 | 156 | 90 | 145 | |
| 1972 | cm | 19.7 | 39.7 | 22.3 | 43.0 | ± 1.81 |
| | % | 100 | 202 | 113 | 218 | |
| 1973 | cm | 14.3 | 24.0 | 27.0 | 48.0 | ± 1.17 |
| | % | 100 | 168 | 189 | 336 | |

In the first year, 1971, there are effects only of the fertilization. The height increment was increased by abt. 50 %.

In 1972 the effects of fertilization have been doubled, and effects of irrigation begin to manifest themselves. Neither in 1971 nor in 1972 there seems to be any interaction of irrigation and fertilization.

In 1973 the effect of fertilization (68 %) is somewhat lower than in 1972. There is a considerable effect of irrigation (89 %) and a very strong effect of fertilization + irrigation (236 %). This figure shows that there is an intensive positive interaction of fertilization and irrigation.

## DISCUSSION

The plantation in which the experiment was established was, as mentioned, a typical heathland plantation with heather covering all the ground between the trees. Most of the plants were marked by having stayed in check. It was, therefore, to be expected that some time (some years?) would

pass before effects, if any, would become of an appreciable magnitude. An assimilation apparatus corresponding to a production on a considerably higher level than the original one was to be built up.

In 1973 the average top shoots in the best plots, that is, those that had been fertilized + irrigated, was 48 cm. This height increment corresponds to Site Class I.

The figures in Table 2 indicate that for the 0 plots there is a relationship of height increment to precipitation rate during the growing season.

For the irrigated plots and for the fertilized + irrigated plots there is an increase in height growth from 1972 to 1973. This may have some connexion with the circumstance mentioned earlier that in a plantation like the one in question there has to be built up an assimilation apparatus before the attainment of an increment corresponding to the higher level of growth factors may be expected.

## ACKNOWLEDGMENTS

The establishment of this experiment was made possible only by the State Forest Service placing irrigation system and area at our disposal. Mr. *Dam,* the local ranger, has been of great help in undertaking the day-to-day management of the experiment. We should like to take this opportunity of acknowledging the helpfulness extended to us.

## RESUMÉ

I 1971 blev der i en rødgrankultur på hedeflade i Gludsted plantage anlagt et forsøg med følgende behandlinger:

Vanding til noget nær optimale vandforsyningsforhold,
gødskning med de tre hovednæringsstoffer, og
både vandet og gødet.

Målt på højdetilvæksten reagerede granerne for gødskning allerede i anlægsåret. I andet år efter anlægget blev gødningseffekten næsten fordoblet, og i dette år viste der sig også svag reaktion på vanding. I det tredje år efter anlægget var reaktionen på vanding større end reaktionen på gødskning, og de parceller, der var både gødede og vandede, havde nu en højdetilvækst, der var mere end tre gange så stor som de ubehandlede parcellers, d.v.s. omtrent som rødgran af bonitet 1.

## LITERATURE

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