Summary

The formula proposed here for evaluation of germination test has taken into account both daily germination speed for each day, and also total germination percent which gives as composite value called germination value

$$GV = \frac{\sum DGS}{N} \times GP \times 10$$

GV is germination value. DGS is daily germination speed which is obtained by dividing the cumulative germination percent by the number of days and can be calculated for each day or at 2 day intervals depending on collection of data. GP is the percent of germination at the end of the test. N is frequency of DGS. This formula indicates when test could be considered terminated, by determining the maximum GV. The proposed formula is applicable for most tree seeds, and is practically very objective and it could be used to standardize germination value in seed germination tests.

Key words: New formula, seed germination value.

Zusammenfassung

Die in dieser Arbeit vorgestellte Formel für die Beurteilung von Keimtests berücksichtigt sowohl die tägliche Keimgeschwindigkeit, als auch das Gesamtkeimprozent. Aus beiden zusammen ergibt sich dann der sog. Keimwert nach der Formel:

$$GV = \frac{\Sigma DGS}{N} \times GP \times 10$$

GV ist der Keimwert, DGS die tägliche Keimgeschwindigkeit, welche ermittelt wird, indem man das kumulative Keimprozent durch die jeweilige Anzahl der Tage dividiert. Es kann sowohl für jeden Tag einzeln, als auch für Intervalle von 2 Tagen errechnet werden, je nach Zweckmäßigkeit der Datenerhebung. GP ist das Keimprozent am Ende des Tests und N die Häufigkeit der DGS.

Durch die Bestimmung des maximalen GV, zeigt diese Formel auch an, zu welchem Zeitpunkt der Test als beendet angesehen werden kann.

Aufgrund der nach unseren Feststellungen objektiven Ergebnisse dieser Formel, könnte sie zur Standardisierung von Samenkeimtests dienen.

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Short Note

Investigations on the Dependence of Flowering in Spruce (Picea abies (L.) Karst.) upon Age and Hormone Treatment

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Introduction

Since 1950 seed orchards have been established for all important forest tree species. Unfortunately the beginning of fructification, especially in Norway spruce, has been delayed for a long time. Therefore many scientists all over the world (MELCHIOR, 1961 a, 1961 b; HASHIZUME, 1968; and many others) have worked to solve the problems of fructification in forest tree species. Again and again it appeared in these studies that fructification in Pinaceae depends very strongly on the age of the plants. In 1973, investigations were started at our institute to elucidate whether Norway spruce plants react differently to treatments with growth regulators at different ages.

Materials and Methods

In the spring of 1973, 20 3-year-old seedlings and grafts of spruce were sprayed in a greenhouse 3 times at weekly intervals with 100 ppm gibberellic acid (GA_3), 1000 ppm indoleacetic acid (IAA) or 10 ppm kinetin (6-furfurylamino purine = KI) as soon as the buds began to open. Subsequently the plants were sprayed 3 tirnes with 2000 ppm CCC ((2-chloroethyl)-trimethyl-ammonium chloride) or 1000 ppm

maleic hydrazide (MH), so that all possible combinations between first and second treatments contained 10 seedlings and 10 grafts. Ten seedlings and 10 grafts remained untreated as controls.

In a parallel trial in a 16-year-old seed orchard (Norway spruce of the upper regions in the "Bayer. Wald") at Landshut/Isar, the plants were sprayed once with 62,5 ppm GA_3, 625 ppm IAA or 6,25 ppm KI, at the time of bud opening. After 4 and 8 weeks the plants were sprayed with 2000 ppm CCC (Cycocel-BASF) or 1000 ppm MH. Spraying was done until run-off under sunny and calm weather conditions. In both trials, 0,1% Tween 20 was added for better adhesion.

Results

Greenhouse trial

Vegetative growth was inhibited significantly by all treatments compared to the controls *(Table 1)*. The different treatments had a significantly distinct influence on the vegetative growth. In no case was flowering observed.

Seed orchard trial

Vegetative growth was not significantly different in and between treated plants and controls. Female flowering (1974) was promoted by treatment with GA_3 + CCC and with KI + MH compared to other treatments and controls (t-values at 2,5, 16 degrees of freedom (df)). Distinct differences between clones run parallel in different treatments (chi-square = 11.63, 48 df). Male flowers were inhibited compared to the control, mostly by GA_3 + CCC. Female flowers were observed mainly in the upper half of the crown, male flowers only in the lower part of the crown (chi-square = 15.65 (12 df) and 2.85 (6 df) show that the observed values agree with the expected values).

Discussion

In the greenhouse trial, the treatments reduced vegetative growth, while in the seed orchard the treatments promoted generative growth. It was necessary to determine which parameter caused this difference. When the small differences in concentration are neglected according to JANSEN (1969), then 3 differences remain: environment (greenhouse/seed orchard), frequency of treatments, and age of plants.

The plants in the seed orchard grew in a similar environment (temperature, light, humidity) as the plants in the greenhouse except for not being in pots. This difference seems not to be very important for the change from vegetative to generative growth. The frequency of treatments effected higher amounts of growth regulators in the cells of the greenhouse plants. If these various amounts would be of any importance in the problem studied, then a high level of growth regulators should influence only vegetative growth and a low level only generative growth. That is improbable because in conifers a high level, at least of gibberellins, seems to be necessary for flower induction (JANSEN, 1969). Therefore the different effect of the growth regulators is probably caused by the different age of the plants. This presumption is strengthened by the observation that in the seed orchard only female flowers were promoted and that female flowers grew mainly in the upper part of the crown which is physiologically older than the lower part (MELCHIOR, 1961 a, 1961 b; SCHAFFALITZKY DE MUCKADELL, 1959). If the action of growth regulators depends on the age of the plants, then one must examine which regulating processes in the cell are responsible for this change of action.

The substances tested act as follows (HESS, 1970): Gibberellic acid is able to activate genetic material, i.e. to introduce de novo synthesis of enzymes. Cytokinins (KI) are purine derivatives, particularly of adenine, which is an essential part of all nucleic acids. Cytokinins are able to stimulate genetic activities.

CCC blocks the biosynthesis of gibberellins. Maleic hydrazide is an antagonist of uracil (COUPLAND and PEEL, 1972) and probably inhibits the synthesis of RNA. Gibberellic acid and KI are able to dissolve the repression of genes by histones (HESS, 1970).

Thus treatment with GA_3 and KI activates genetic material. CCC blocks further biosynthesis of GA_3 and consequently further activation of genes. Maleic hydrazide stops transcription and translation of genetic material. As the mechanism of action is the same in all developmental stages (HESS, 1970), a different effect is only possible by the activation of other genes or parts of chromosomes in 3-year-old plants than in 16-year-old plants. That could be caused by the repression of genes by histones which is not so strong in the beginning maturity phase as in the juvenile phase (WELLENSIEK, 1969). However in conifers histones seem to be unable to prevent activation of genes by gibberellins, as

Table 1. — Comparison of mean shoot growth of 3-year-old Norway spruce grafts and seedlings as affected by different growth regulator treatments.

Grafts	GA + CCC	GA + MH	IAA + CCC	IAA + MH	KI + CCC	KI + MH	Control
GA + CCC	9,5	*	***		**		***
GA + MH		9,0		**		***	***
IAA + CCC			11,8	*	***		—
IAA + MH				10,3		—	**
KI + CCC					8,6	*	***
KI + MH						9,1	**
Control							13,3
Seedlings							
GA + CCC	12,7	—	—		*		***
GA + MH		12,5	***	***		—	***
IAA + CCC			10,9	**	—		***
IAA + MH				12,8		***	***
KI + CCC					13,2	*	***
KI + MH						17,0	***
Control							21,4

Significant comparisons indicated as follows: P = 0.05 (*); P = 0,01 (**); P = 0,001 (***). Non-significant comparisons indicated by (—).

is shown by the successful tests of PHARIS (1966), BONNET-MASSIMBERT (1971) and others with young plants of various species of Cupressaceae.

There is some reason to believe that with increasing age in Norway spruce, new genes or parts of chromosomes become ready to be activated and that the genetic information for the introduction of the generative phase is located on chromosomes farther from genes which control the metabolism of young plants than, for example, in Cupressaceae. In contrast, a selective removing of gene-repression at any locus on chromosomes by histones is very unlikely. If this interpretation of results is correct, aging would be fixed genetically in species and even individuals. Metabolic processes might change with aging by activation of genes which are unchangeably repressed in the juvenile phase. Similar presumptions were made by De Kock and coworkers (cit. VARNER, 1961) who concluded that "the balance between the various processes changes with aging of the organism" and "that no metabolic system is lost or new system introduced during the life of the organisms". Also, RUBNER's thesis (1908) that "an inverse relationship existed between rate of metabolism and duration of life," which is extended by VARNER (1961) to the energy metabolism of the cell, expresses the same thoughts. If much energy is applied to the plant, more genes can be activated. Then it is more possible to reach the generative phase. There is an old experience that plants begin to flower earlier when they are exposed to a climate warmer than at their place of origin.

Abstract

Three- and 16-year old plants of Norway spruce were treated with indoleacetic acid, gibberellic acid, kinetin, chlorocholinechloride and maleic hydrazide. In the 3-year-old plants, the treatment affected only the vegetative growth and in the 16-year-old plants, only the generative growth (female flowers were initiated when gibberellic acid + chlorocholinechloride and when kinetin + maleic hydrazide were applied). Because these substances are able to activate genetic material, it is suggested that in Norway spruce other genes or parts of chromosomes may be activated in the juvenile stage than in the beginning phase of maturity.

Key words: Norway spruce, Flowering, Hormones, Ageing.

Zusammenfassung

Berichtet wird über Versuche mit Indol-3-essigsäure, Gibberellinsäure, Kinetin, Chlorcholinchlorid und Maleinhydrazid an 3- und 16jährigen Fichten *(Picea abies* KARST.). Bei den 3jährigen Pflanzen wirkte die Behandlung ausschließlich auf das vegetative Wachstum, bei den 16jährigen ausschließlich auf das generative Wachstum (Bildung weiblicher Blüten bei Behandlung mit Gibberellinsäure + Chlorcholinchlorid und Kinetin + Maleinhydrazid).

Aufbauend auf der bekannten Fähigkeit dieser Substanzen, genetisches Material zu aktivieren, wird vermutet, daß bei Fichte im Jugendstadium andere Gene oder Chromosomenabschnitte aktivierbar sind als im beginnenden Mannbarkeitsalter.

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