SUOMEN METSÄTIETEELLINEN SEURA — FINSKA FORSTSAMFUNDET

ACTA FORESTALIA FENNICA

67,

ARBEITEN DER
FORSTWISSENSCHAFTLICHEN GESELLSCHAFT
IN FINNLAND

PUBLICATIONS OF THE
SOCIETY OF FORESTRY
IN FINLAND

PUBLICATIONS DE LA
SOCIÉTÉ FORESTIÈRE
DE FINLANDE

HELSINKI 1959

Suomen Metsätieteellisen Seuran julkaisusarjat:

ACTA FORESTALIA FENNICA. Sisältää etupäässä Suomen metsätaloutta ja sen perusteita käsitteleviä tieteellisiä tutkimuksia. Ilmestyy epäsäännöllisin väliajoin niteinä, joista kukin yleensä käsittää useampia tutkimuksia.

SILVA FENNICA. Sisältää etupäässä Suomen metsätaloutta käsitteleviä kirjoitelmia ja pienehköjä tutkimuksia. Ilmestyy epäsäännöllisin väliajoin.

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Suomalaisen Kirjallisuuden Kirjapaino Oy Helsinki 1959

Acta Forestalia Fennica 67.

LIBERATION OF NITROGEN FROM ALDER LEAF LITTER

PEITSA MIKOLA

SELOSTUS:

TYPEN VAPAUTUMINEN LEPÄN LEHTIKARIKKEISTA

HELSINKI 1958

Contents

Suomalaisen Kirjallisuuden Kirjapaino Oy Helsinki 1958

Introduction

The humus layer of the soil constitutes the principal source of nutrients, and in particular of nitrogen, for forest trees. The nutrients lost are, in turn, continuously replaced by needle and leaf litter and other vegetable debris. Consequently, humus quality and tree growth are greatly affected by the amount of litter annually deposited and by its chemical composition as well as by the rate of its decomposition and the rate of liberation of nutrients. A comprehensive literature concerning these questions has been accumulating ever since the classical work of EBERMAYER (1876). These studies have shown, among other things, that the litters of different plant species differ greatly in regard to their nutrient content and other properties, likewise, there is great variation in the litters of the same species from different sites, and the decomposition of litter and liberation of nutrients depend in a complicated manner on the chemical composition of the litter concerned and on other factors too (HESSELMAN 1926, MELIN 1930, WITTICH 1939, BROADFOOT & PIERRE 1939, CHANDLER 1941, VIRO 1955, BONNEVIE-SVENDSEN & GJEMS 1957, etc.)

The aim of the present study was to compare different litters from the standpoint of their value as soil fertilizers. This was done experimentally by growing pine seedlings in pot cultures in which known amounts of different litters had been mixed with the soil. The experiments revealed a striking difference between alder leaf litter and all the other litters tested.

Experimental

The experiments were conducted as follows: A clay pot of 1 liter capacity was filled with soil, and 50 g of air-dried litter was thoroughly mixed with the soil. The soil used was a sandy loam subsoil obtained from a spruce stand of Oxalis-Myrtillus type at a depth of 50 cm and contained practically no humus. 15 seeds of Scots pine (*Pinus silvestris*) were sown and after the seedlings had emerged they were thinned to leave 10 seedlings per pot. (Since some seedlings later died, the number of seedling per pot at the time of harvesting varied from

5 to 10.) The pots were kept sunk in a nursery bed. During the experiment (2—3 years) they were kept clear of weeds and litters falling from trees in the neighbourhood, and watered some times during prolonged periods of drought. The experiments were made at the Korkeakoski Forestry Station of the University of Helsinki, in 1953—56.

The litters were collected in the autumn from trees or beneath them immediately after the leaf-fall. They were dried and stored at room temperature. The same litters were used by the author in field and laboratory experiments on the microbial decomposition of litter (Mikola 1954). Before being mixed with the soil, the litters were ground finely. Their contents of ash and nitrogen and pH are shown in Table 1.

Table 1. The pH, ash and nitrogen contents of the litters.
Taulukko 1. Karikkeiden pH sekä tuhka- ja typpipitoisuudet.

Kind of litter *Karikelaji*	pH	Ash *Tuhka* %	Nitrogen *Typpi* %
Pinus silvestris	4.6	1.53	0.49
Larix sibirica	3.7	3.84	0.54
Betula (Expts. 1—2)	5.2	4.10	1.05
» (Expt. 3)	5.6	4.87	1.49
Populus tremula	5.3	6.36	0.72
Alnus incana	6.1	5.85	2.73
Alnus glutinosa	4.7	4.48	2.57
Sorbus aucuparia	5.6	8.37	0.83
Tilia cordata	5.5	8.42	1.16
Acer platanoides	4.4	11.92	0.63
Corylus avellana	5.8	7.63	1.30
Eupteris aquilina	5.9	8.88	0.81
Deschampsia flexuosa	5.1	1.86	0.37

Expt. 1. The litters used are mentioned in Table 2. Each kind of litter was put into four pots (birch in two pots only), two of which were sown with pine and two with lettuce. Four pots served as controls with same soil but without litter. This was done in the spring of 1953.

Lettuce germinated well in all pots but grew poorly and died before the autumn on all litters except that of *Alnus incana* and in one pot of *Eupteris aquilina*. The reason for this was evidently lack of nutrients and perhaps also high acidity.

Only slight differences in the growth of pines on different litters were seen during the first summer. On *Alnus* litter, however, the seedlings were best, being deep green, and on *Pinus* and *Populus* litters poorest, being yellowish.

Table 2. Size of pine seedlings grown on different litters at the age of 2 years (Expt. 1).
Taulukko 2. Eri karikkeilla kasvaneiden 2-vuotiaiden männyn taimien suuruus (koe 1).

Kind of litter *Karikelaji*	Height *Pituus* cm	Number of needle pairs *Neulasparien luku*	Needle length *Neulasten pituus* cm	Shoot weight *Verson paino* mg	Root weight *Juuriston paino* mg
Control — *Kontrolli* (7)[1]	3.6	6	4.2	65	39
Pinus (8)	2.3	3	1.9	31	17
Betula (8)	2.9	4	1.8	28	20
Populus (8)	2.4	3	1.0	27	13
Alnus (5)	3.1	7	4.7	84	44
Eupteris (10)	2.8	4	2.0	34	15

Table 3. Size of pine seedlings grown on different litters at the age of 3 years (Expt. 1).
Taulukko 3. Eri karikkeilla kasvatettujen 3-vuotiaiden männyn taimien suuruus (koe 1).

Kind of litter *Karikelaji*	Height *Pituus* cm	Number of needle pairs *Neulasparien luku*	Needle length *Neulasten pituus* cm	Shoot weight *Verson paino* mg	Root weight *Juuriston paino* mg
Control — *Kontrolli* (8)	3.4	11	2.2	58	39
Pinus (9)	3.0	9	1.9	53	29
Populus (5)	2.7	5	1.2	22	19
Alnus (7)	7.8	25	3.6	319	112
Eupteris (7)	5.0	12	4.3	141	52

The first pot of each litter was harvested in the fall of 1954 and the second in the fall of 1955. The seedlings were carefully removed, dried at room temperature and weighed. The results, calculated per seedling, are presented in Tables 2 and 3.

The development of the root system, e.g. the number of mycorrhizae, was proportional to the size of the seedlings.

Expt. 2. The pots in which lettuce was grown in 1953 were resown with pine in the spring of 1954. Accordingly, the litters had decomposed in the soil for one year before sowing. The seedlings were harvested at the age of 3 years. The mensurational data for the seedlings are presented in Table 4.

Expt. 3. The procedure was the same as in Expt. 1; more kinds of litter, however, were included. The seeds were sown in the spring of 1954 and the seedlings were harvested at the age of 3 years. The results are presented in Table 5.

1 Number of seedlings
Taimien lukumäärä

Table 4. The size of pine seedlings grown on different litters at the age of 3 years (Expt. 2).
Taulukko 4. Eri karikkeilla kasvaneiden 3-vuotiaiden männyn taimien suuruus (koe 2).

Kind of litter *Karikelaji*	Height *Pituus* cm	Needle length *Neulasten pituus* cm	Shoot weight *Verson paino* mg	Root weight *Juuriston paino* mg
Control — *Kontrolli* (9+5)	3.9±0.3	4.5±0.4	107±14	107±15
Pinus (10+9)	3.3±0.1	2.0±0.2	37±3	32±4
Betula (9)	4.3±0.3	4.0±0.2	102±17	73±12
Populus (9+6)	4.3±0.3	4.2±0.3	93±9	81±8
Alnus (8+5)	6.2±0.5	3.9±0.4	212±29	119±21
Eupteris (10+8)	4.9±0.3	3.8±0.2	111±11	101±12

Table 5. The size of pine seedlings grown on different litters at the age of 3 years (Expt. 3).
Taulukko 5. Eri karikkeilla kasvaneiden 3-vuotiaiden männyn taimien suuruus (koe 3).

	Height *Pituus* cm	Needle length *Neulasten pituus* cm	Shoot weight *Verson paino* mg	Root weight *Juuriston paino* mg
Control — *Kontrolli* (9+8)	5.2±0.2	4.5±0.2	142±14	130
Pinus silvestris (10+10)	3.2±0.1	1.4±0.1	32±4	26
Larix sibirica (10+7)	4.8±0.4	3.2±0.2	91±16	88
Betula (7+6)	5.2±0.3	4.8±0.6	138±16	136
Populus tremula (10+9)	3.8±0.2	3.5±0.3	54±4	43
Alnus incana (10+7)	6.6±0.4	5.6±0.5	229±27	202
Alnus glutinosa (9+9)	7.7±0.3	5.4±0.3	311±24	206
Sorbus aucuparia (9+8)	3.9±0.2	3.8±0.4	67±5	67
Tilia cordata (9+7)	4.6±0.1	3.9±0.4	102±11	92
Acer platanoides (10+9)	3.5±0.1	2.4±0.2	43±3	41
Corylus avellana (10)	5.0±0.3	4.4±0.4	84±10	66
Eupteris aquilina (10+9) ..	4.5±0.2	4.1±0.2	93±10	82
Deschampsia flexuosa (10) ..	3.6±0.2	2.1±0.3	44±3	27

Discussion

Litter mixed in the substrate has little effect on the growth of pine seedlings in the first summer, since growth takes place mainly at the expence of the nutrient reserve present in the seed. In subsequent years, however, the effect is very great.

The initial effect of different litters on seedling growth is very varied. Most

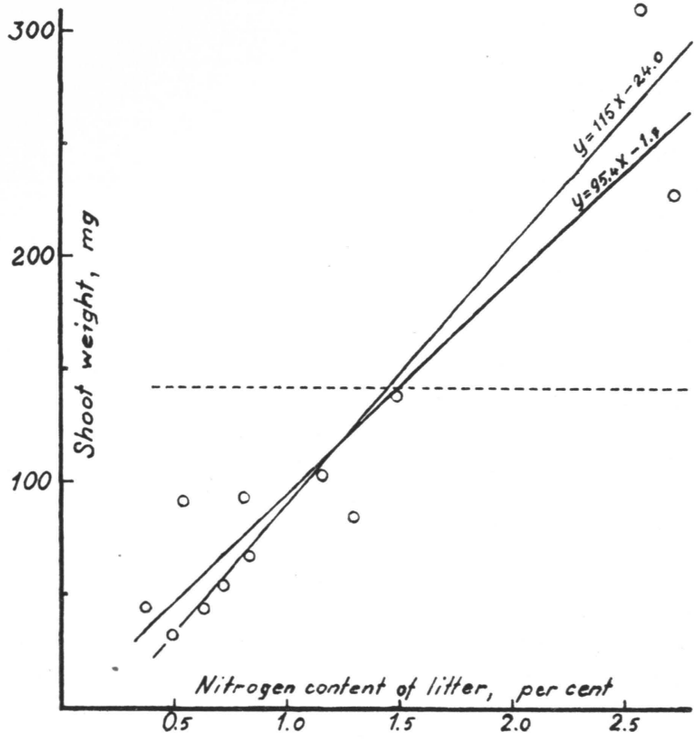

Fig. 1. Relation between nitrogen content of litter and shoot weight of pine seedlings. The dotted line represents the shoot weight of control seedlings (Expt. 3).
Kuva 1. Karikkeiden typpipitoisuuden ja männyn taimien painon välinen suhde. Katkoviiva osoittaa ilman karikkeita kasvatettujen taimien painon (Koe 3).

of them are harmful; the only exception is formed by the leaves of alder (both grey and black alder), which differ greatly from all other litters, their influence being favourable from the first summer on.

The favourable or unfavourable influence of litters is mainly due to their nitrogen content. The lower the nitrogen content of the litter the poorer is the growth of the pine seedlings. This is clearly illustrated in Fig. 1. The correlation coefficient between the nitrogen content of the litter and the shoot weight of seedlings is 0.955 ± 0.013 (Expt. 3); thus the influence of other properties of the litter is virtually negligible. Likewise, Scott (1952), in corresponding experiments, could find no relationship between the growth of aspen cuttings and the mineral nutrient content of litters.

It is a well known fact that addition to the soil of plant remains that are rich in cellulose or other carbohydrates and poor in nitrogen reduces the crop, because cellulose-decomposing microbes utilize all the available nitrogen. According to WAKSMAN (1952), the organic matter added to soil should contain at least 1.5—1.7 % nitrogen, to be sufficient for its decomposition. If the nitrogen content is less than 1.5 %, the microbes take nitrogen from the soil; if the nitrogen content is higher, part of the nitrogen is liberated as NH_3. The results here reported are in good agreement with these data. Alder leaves were the only kind of litter that could furnish nitrogen for pine seedlings. Other litters contained less than 1.5 % nitrogen, and accordingly their immediate influence was harmful.

During the course of decomposition, the nitrogen content of litter increases. When the litters had been in the soil a whole year before the sowing of pine, their harmful effect was markedly reduced (Expt. 2).

From the above results some practical conclusions can be made. Tree leaves and other forest litter are often composted in forest nurseries. Evidently addition of nitrogen to the compost is necessary; otherwise the compost, when added to the soil, may have a harmful effect.

Alder leaves differ greatly from other forest litters in regard to their nitrogen content and influence on seedling growth. In symbiosis with *Actinomyces* in its root nodules, the alder is able to utilize atmospheric nitrogen and thus to raise the nitrogen content of the soil. As has been shown by VIRTANEN (VIRTANEN & SAASTAMOINEN 1933, VIRTANEN 1957), considerable quantities of nitrogen move directly from the roots of alder to the soil. But the effect exerted on the soil by its leaf litter is probably more important. The percentage of nitrogen removed from the leaves before falling is much smaller in the alder than in other trees (VIRO 1955), and the amount of nitrogen that is added to the soil in the annual litter crop is many times larger in an alder stand than in stands of other trees. Although the alder is a commercially worthless tree and is usually considered a weed tree, some possibility may exist in practical silviculture to make use of its unique virtue.

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SELOSTUS:

TYPEN VAPAUTUMINEN LEPÄN LEHTIKARIKKEISTA

Tässä esitettyjen kokeiden tarkoituksena oli alkuaan vertailla eri puulajien karikkeiden lannoitusarvoa. Kokeissa paljastui tässä suhteessa jyrkkä ero lepän lehtikarikkeiden ja kaikkien muiden kokeiltujen karikkeiden välillä.

Kokeet tapahtuivat siten, että 1 litran vetoinen kukkaruukku täytettiin maalla (hiesuista moreenia 50 cm:n syvyydestä OMT:n kuusikosta) ja siihen sekoitettiin 50 g ilmakuivia jauhettuja karikkeita. Ruukkuihin kylvettiin mäntyä (kokeessa 1 osaan ruukuista salaattia). Ruukut pidettiin lähes reunaa myöten maahan upotettuina. Koeaika oli 2—3 vuotta, jona aikana ruukut pidettiin puhtaina rikkaruohoista sekä kuivina aikoina kasteltiin. Kokeen päätyttyä männyn taimet poistettiin ruukuista, kuivattiin ja mitattiin.

Kokeissa käytetyt karikkeet on lueteltu taulukossa 1. Samoja karikkeita kirjoittaja käytti aikaisemmin julkaistuissa karikkeiden hajaantumista koskevissa kokeissa (MIKOLA 1954). Kokeiden tulokset ovat taulukoissa 2—5. Niiden perusteella voidaan tehdä seuraavia päätelmiä.

Maahan sekoitettujen karikkeiden vaikutus taimien kasvuun oli ensimmäisenä kesänä vähäinen, koska kasvu tapahtuu pääasiassa siemenessä olevan vararavinnon voimalla. Seuraavina kesinä karikkeiden vaikutus oli hyvin voimakas. Karikkeiden typpipitoisuuden ja taimien kasvun välinen riippuvuus oli selvä (korrelaatiokerroin 0.955 ± 0.013; vrt. kuva 1).

Jos karikkeet sisälsivät typpeä vähemmän kuin 1.5 %, oli niiden vaikutus haitallinen. Lepät (*Alnus incana* ja *A. glutinosa*) olivat ainoat puulajit, joiden lehtikarikkeet sisälsivät typpeä niin paljon, että ne vaikuttivat taimien kasvuun edullisesti ensimmäisestä kesästä lähtien.

Kokeista voidaan tehdä mm. sellainen käytännöllinen päätelmä, että lehtikarikekompostiin on syytä lisätä typpeä, jotta komposti ei esim. taimitarhamaahan sekoitettuna vaikuttaisi käytettävissä olevaa typpeä vähentävästi.

Kuten tunnettua leppä pystyy juurinystyröissä olevan sädesienen avulla yhteyttämään ilmakehän vapaata typpeä ja lehtikarikkeittensa välityksellä kartuttamaan maan typpivaroja (VIRTANEN 1957). Tämä on niin arvokas ominaisuus, että sitä olisi pyrittävä käyttämään hyväksi myös käytännöllisessä metsänhoidossa.