Acarologia

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Subscriptions: Year 2021 (Volume 61): 450 €
http://www1.montpellier.inra.fr/CBGP/acarologia/subscribe.php
Previous volumes (2010-2020): 250 € / year (4 issues)
Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France
ISSN 0044-586X (print), ISSN 2107-7207 (electronic)

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under the reference ID 1500-024 through the « Investissements d’avenir » programme (Labex Agro: ANR-10-LABX-0001-01)

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EFFECT OF FOREST FERTILIZATION ON THE SPRUCE SPIDER MITE _OLIGONYCHUS UNUNGUUIS_ (JACOBI) (ACARINA, TETRANYCHIDAE)

BY K. LÖYTTYNIEMI* and K. HELIÖVAARA*

OLIGONYCHUS UNUNGUUIS

PICEA ABIES

NITROGEN

PEST CONTROL

FINLAND

ABSTRACT: Egg number of _Oligonychus ununguis_ on Norway spruce (_Picea abies_) needles was investigated in a fertilization experiment in southern Finland. The highest number of winter eggs was recorded on the plots treated with a combination of nitrogen and phosphorus. According to needle nutrient analysis, the number of eggs was positively correlated with needle nitrogen concentrations, but not with those of phosphorus, potassium or calcium.

OLIGONYCHUS UNUNGUUIS

PICEA ABIES

AZOTE

LUTTE

FINLANDE

RÉSUMÉ: Le nombre des œufs d’_Oligonychus ununguis_ sur les aiguilles de l’épicéa commun (_Picea abies_) a été étudié dans un essai de fertilisation en Finlande du Sud. Le nombre plus élevé des œufs hivernaux a été noté dans une parcelle traitée par une combinaison d’engrais azotés et phosphatés. Une analyse de l’état nutritif des aiguilles a révélé une corrélation positive entre le nombre des œufs et la concentration de l’azote mais l’absence de relation avec les phosphore, potassium et calcium.

INTRODUCTION

The spruce spider mite _Oligonychus ununguis_ (Jacobi) occurs on coniferous trees, especially on spruce (_Picea_) species throughout the holarctic region. In Finland it is the most serious sucking needle pest of Norway spruce (_P. abies_ (L.) Karst.). The mite damages or even kills young trees in nurseries, plantations and forests, but it also infests older trees causing premature needle cast (LÖYTTY-NIEMI, 1969, 1970).

Forest fertilization is a fairly common practice in Finland (e.g., VIRO, 1972). The effect of forest fertilization on the occurrence of _O. ununguis_ has not, however, been studied in Finland, and very little information is available from elsewhere (THALENHORST, 1972). Consequently, studies were carried out on the relationship between the population density of _O. ununguis_ and the macronutrient concentrations of spruce needles after fertilization.

The basic objective was to evaluate the effect of forest fertilization on the amount of damage caused by this pest.

MATERIAL AND METHODS

The study site was situated in an experimental forest of the Finnish Forest Research Institute at Liljendal, southern Finland (60°32’ N, 26°05’ E). The fertilization experiment consisted of eight 50 x 50 m sample plots (NP, CaP, CaN, O, Ca, N, P, CaNP factorial experiment, see VIRO, 1972) established in a mature Scots pine (_Pinus sylvestris_ L.) stand growing on a poor _Calluna_ site type. The stand also contained young Norway spruces growing sporadically as undergrowth in the study area. These spruce trees formed the study material. The spruces were slow-growing, 20-30 cm high, and chronically infested by the spruce spider mite.

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The plots had been fertilized every third to fourth year as follows (LIPAS 1979):

1958: Ammonium sulphate, 84 kg N/ha, finely ground rock phosphate, 28 kg P/ha, and 2000 kg limestone/ha.
1962: Ammonium sulphate, 84 kg N/ha, on the N plots.
1965: Urea 92 kg N/ha on the N plots.
1969: Urea 92 kg N/ha on the N plots.

At the end of October 1972 all the normally developed current shoots (13 ... 25 per tree) were removed from the twelve trees nearest to the center of each plot and measured. Winter eggs of *O. ununguis* were counted and recorded as a number per cm of shoot (cf. THALENHORST, 1972). After the eggs had been counted, the needles were removed from the shoots and milled to give one sample per tree for the nutrient analysis. Total nitrogen, phosphorus, potassium and calcium concentrations were determined using standard needle analysis methods (HALONEN et al., 1983).

The material totalled 96 Norway spruces, and 3828 spruce spider mite eggs.

**RESULTS**

*Fertilization and egg number*

Infestation by *Oligonychus ununguis* averaged 0.31 (S.D. 0.42) winter eggs per cm of spruce shoot. The eggs were rather unevenly distributed over the study area (Fig. 1), but so statistically significant differences could be detected between egg number on the sample plots ($F = 1.17, p = 0.326$ df = 7, 87, analysis of variance).

![Egg density graph](image)

**Fig. 1**: Number of winter eggs of *Oligonychus ununguis* per cm of spruce shoot on plots given different fertilizer treatments. Bars indicate halved standard deviations.

The sample plots were divided into the plots given nitrogen (+N plots) and those not (−N plots) for further analysis. Four years after the last nitrogen application the growth response of the spruces was rather small. The average shoot growth of the spruces growing on the +N plots was 83.4 mm (S.D. 14.6), and 77.3 mm (S.D. 17.0) on the −N plots, the difference being statistically non-significant ($F = 3.50, p = 0.065$, df = 1, 94). 0.38 (S.D. 0.50) eggs were recorded per cm of shoot on the +N plots, and 0.25 (S.D. 0.31) on the −N plots. Owing to the high between-tree variation, no
statistically significant differences were found in egg number per shoot between these two groups \( (F = 2.07, p = 0.154, df = 1, 93) \).

Factorial analysis (see Lipas, 1979) carried out on the data indicated that the egg number would be highest on sample plots treated with a combination of nitrogen and phosphorus. Consequently, the plots were further divided into -NP and +NP ones. Egg number was significantly higher \((F = 6.08, p = 0.016, df = 1, 93)\) on the +NP plots (mean 0.49, S.D. 0.59) than on the -NP (mean 0.25, S.D. 0.32) ones.

Needle nutrient concentrations and egg number

Only weak correlations \((r = -0.19 \ldots 0.09, \text{NS}, df = 94)\) were found in the pooled data between the height growth of the shoots and the nutrient concentrations of the needles. The egg density correlated with the nitrogen concentrations of the spruce needles (Fig. 2), but not with the calcium, potassium or phosphorus concentrations. The same tendency was also true for egg number, when the total number of eggs (i.e. ignoring shoot length) was taken into account.

\[
y = -0.23 + 0.56x, \quad r = 0.22, \quad p<0.05
\]

**Fig. 2**: Dependence of the winter egg number of *Oligonychus ununguis* on the nitrogen concentration of the spruce needles.

**DISCUSSION**

Increased soluble nitrogen levels in a plant usually increase the growth and reproduction of herbivorous insects (Mattson, 1980). It is also well established that fertilization and changes in the nutrient concentrations in the host plant affect the reproduction and attacking level of phytophagous mites. Most of the information concerns *Tetranychus urticae* on herbaceous plants in greenhouses and gardens. Of the tetranychids that occur on woody plants, *Panonychus ulmi* has been especially studied. The ecology of *P. ulmi* in temperate climates is rather similar to that of *O. ununguis* (Löyttyniemi and Tulisalo, 1974). Nitrogen fertilization and increased foliar nitrogen concentrations have usually induced a significant build-up of *T. urticae* and *P. ulmi* (e.g. Fritsche et al., 1957;
Besides mites, many sucking insect pests also benefit from nitrogen fertilization (e.g. Brüning, 1967; Carrow and Graham, 1968; Markkula and Tuttanen, 1969; Thalenhorst, 1972; Heliövaara et al., 1983). The results of studies on the relationship between phosphorus, potassium and calcium concentrations and tetranychids have usually been contradictory and depend on the study plant, pest species and local conditions. However, in some cases the highest numbers of mites have been recorded on plants with potassium deficiency (e.g. Fritsche et al., 1957; Leroux, 1959; Mathys et al., 1968; Markkula and Tuttanen, 1969).

The effect of forest fertilization on the occurrence of O. ununguis has earlier been investigated in Central Europe (Martignon and Zemp, 1956; Thalenhorst, 1963, 1972). The population density of O. ununguis in young spruce plantations appeared to be higher in plots treated with nitrogen than in nitrogen-free ones. However, the effect of exposure on the population density hid the effect of nitrogen alone, as well as the potential effects of potassium, phosphorus and calcium fertilizers. No foliage analyses were carried out.

Our present results are in agreement with earlier observations. Mite density was slightly higher on the plots treated with nitrogen, especially when combined with phosphorus. The effect of nitrogen fertilization, however, might have been more distinct if the study had been carried out after one to two years after application, instead of four as now.

In addition to the total nitrogen concentration, nitrogen fertilization also causes an increase in the amino acid content of plants (e.g. Durzan and Steward, 1967; Tulsalo, 1971). It has been demonstrated that there is a positive correlation between the content of essential amino acids in spruce needles and the occurrence of O. ununguis (Löytyniemi and Tulsalo, 1972).

Although a weak relationship was found between nitrogen concentration and the occurrence of O. ununguis, the present results suggest that the level of practical fertilization does not cause any drastic changes in the population density of O. ununguis under Finnish conditions. It is evident that the natural variation in the nutrient concentrations between the spruce trees obscures the effect of fertilization. The results also suggest that large experimental plots are not suitable for studying the effects of fertilization on this kind of pest, the population density of which is highly dependent on the exposure and other external factors (cf. Löytyniemi, 1969, 1970).

Acknowledgements

The authors express sincere thanks to Tuula Hiltunen and Eero Kempfi for assisting in the laboratory, and John Derome for commenting on the manuscript.

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