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# Relationship between Japanese Pear Scab Development and Nutrients Content in Leaves on Trees Given Different Amounts of Nitrogen Fertilizer

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**Abstract**

The correlation between the development of Japanese pear scab (caused by *Venturia nashicola*) on leaves and the content of total nitrogen, total carbon, phosphorus, potassium, calcium, magnesium, iron and manganese in the leaves on trees given different amounts of nitrogen fertilizer was investigated. With an increase of nitrogen fertilizer, the content of total nitrogen and manganese in leaves increased while calcium content decreased. The content of total carbon, phosphorus, potassium, magnesium and iron did not show any obvious change. The ratio of diseased leaves, degree of disease development and degree of conidial formation increased with increasing amounts of given nitrogen fertilizer. Significant correlations ($P=0.05$) were recognized between total nitrogen content and the degree of disease development on 3rd and 7th position leaves from top leaf, the degree of conidial formation on 11th position leaf, calcium content and degree of disease development on 7th position leaf, and manganese content and degree of conidial formation on 7th position leaf. These results show that with an increase in nitrogen fertilizer there is an increase in total nitrogen and manganese content and a decrease in calcium content in leaves, and a higher susceptibility to Japanese pear scab was induced.

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**Key words:** nitrogen fertilizer application, *Venturia nashicola*, scab development on leaves, nutrient element content in leaf.

## INTRODUCTION

Generally plant disease becomes severe with excessive application of nitrogen fertilizer[1], and that is one of the major factors of disease development and severe damage with rice blast disease[3,6], *Endothia* canker of chestnut[10] and canker of Japanese pear[5]. In regard to Japanese pear scab, it has been previously shown that excessive application of nitrogen fertilizer is a major factor on severe scab disease development and usage of nitrogen fertilizer has to be integrated into the disease control. Several reports previously published on the subject recognized that the controlled application of nitrogen fertilizer was a primary means of controlling pear scab. For example, Okumura[7] indicated that the excessive application of nitrogen fertilizer was the major factor leading to severe outbreaks of the disease and Bokura[2] recommended the use of organic fertilizer to prevent the decline in the vigor of fruit trees. However, experimental data which lead to these conclusions can not be found in the literature.

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In this paper, the relationship between the ratio of diseased leaves, degree of disease development and degree of conidial formation on leaves and leaf content of total nitrogen, total carbon, phosphorus, potassium, calcium, magnesium, iron and manganese was investigated.

## MATERIALS AND METHODS

***Nursery trees for inoculation tests.*** Budwood of Japanese pear cv. Chojuro was grafted on potted seedlings of rootstock variety, "Manshumamenashi" (*Pyrus betulaefolia*) in February, 1988 and grown in a non-heated greenhouse. The top leaves of every growing shoots were marked with oily ink just before inoculation.

***Soil and fertilizer.*** Volcanic ash subsoil (total nitrogen 0.21%, total carbon 2.6%, CEC 18.6 meq/100 g dry soil, and phosphate absorption coefficient 2385) was used as basic soil type. Nitrogen fertilizer was applied at 0, 1/4, 1/2, 1, 2, 3, 4 and 5 times of the standard recommended amounts of 200 kg-N per 1 ha with ammonium sulfate, phosphorus at 200 kg with super phosphate and 100 kg of fused magnesium phosphate within a total amount of 300 kg-$P_2O_5$ per 1 ha and potassium at 150 kg-$K_2O$ per 1 ha with potassium chloride. Grafted trees were planted in No. 10 earthen pot with soil mentioned above in late March, 1988. The potted trees were grown until time of inoculation in a non-heated greenhouse. The experiments were conducted with one treatment per one grafted tree with 3 replications.

***Inoculation.*** Conidia collected from lesions on leaves and young fruits of cv. Chojuro trees which had never been sprayed with fungicides were suspended in distilled water containing 0.01% spreader (to prevent clumping of conidia) and 1% sucrose (to stimulate conidial germination). The concentration of conidia suspension was adjusted to $8.2 \times 10^4$/ml by a hemacytometer and the suspension was sprayed onto the both sides of the leaves of the grafted trees to be thoroughly drenched. The germination ratio of the conidia in suspension was 75.4%. Inoculated trees were maintained in dew chambers at 20°C for 48 hr with fluorescent lamp illumination. Inoculated trees were then transferred to the northern side of a building where the amount of solar radiation was rather limited and inoculum source of the disease was absent. The pots were watered when their surface soil was almost dry.

***Observation of disease development.*** Disease development was observed on the top 13 leaves from marked leaf of every shoot at 15 and 31 days (June 8 and 24) after inoculation. The degree of disease development and conidial formation were assigned to one of the following 5 categories based on lesion area and amounts of produced conidia, respectively. The categories of disease development and conidial formations is as follows.

| Grade | Index of diseased development (leaf area) | Index of conidial formation |
|---|---|---|
| 0: | 0% (healthy) | None |
| 1: | Less than 10% | Rarely |
| 2: | Between 11–25% | A few |
| 3: | Between 26–50% | Moderately |
| 4: | More than 51% | Abundantly |

Disease severity and conidial formation were calculated by the following equation, $\{(1n_1+2n_2+3n_3+4n_4)\div 4N\} \times 100$. The $n_1$ to $n_4$ represent the number of the leaves belonging to each category and $N$ represents the number of observed leaves.

***Analysis of nutrient elements in leaves.*** The leaves of 3rd position (upper leaf position of the highly susceptible range to the causal fungus), 7th position (lower leaf position of the highly susceptible range to the causal fungus) and 11th position (almost the lowest leaf position of showing the symptoms) from marked leaf on shoot were sampled for analysis at just before inoculation. The same position leaves of cv. Chojuro trees at the Fruit Trees Laboratory (abbreviate to Fruit Trees Lab.) orchard in Chiba Prefec. Agric. Exp. Stn. that had been applied the standard amount of fertilizer (200 kg-N, 183 kg-$P_2O_5$ and 167 kg-$K_2O$ per 1 ha, respectively) were sampled at the same day as the control plot for analysis. These leaves were dried in a oven at 60°C and stored under dry conditions. Total nitrogen and total carbon were analyzed by using NC analyzer after each of the leaves had been milled. After the samples were digested with nitric and perchloric acids, acid solutions with 1 M-hydrochloric acid were prepared. Phosphorus was analyzed by colorimetric determination and the other elements such as potassium, calcium, magnesium, iron and manganese were measured by atomic absorption spectrochemical analysis[8].

## RESULTS

***Total nitrogen and total carbon content in leaves***

Total nitrogen content in the 3rd, 7th and 11th position leaves for the various amounts of nitrogen fertilizer applied are shown in Table 1. Throughout, total nitrogen content tended to increase at 7th and 11th position leaves in direct relation to an increase in the amounts of nitrogen fertilizer applied. On the other hand, the total nitrogen concentration in 7th position leaf of cv. Chojuro grown in the Fruit Trees Lab. orchard was 2.69%. This value was almost midway between the values for 1/4 and 1/2 N treated pots. Total carbon concentration in dried leaves was about 45%, regardless of the leaf position or the amounts of nitrogen fertilizer applied (Table 1).

***Contents of other elements in leaves***

The samples of only 7th and 11th position leaves were analyzed because the amount of sample material of 3rd position leaf was too small for analysis. Calcium content in both 7th and 11th position leaves gradually decreased and manganese content gradually increased with an increase in the amount of nitrogen fertilizer applied. However, the phosphorus and magnesium contents did not change and the potassium and iron contents did not exhibit a clear tendency among the different amounts of nitrogen fertilizer applied (Table 2).

***The relationship between the ratio of diseased leaves, degree of disease development and degree of conidial formation to the amount of nitrogen fertilizer applied***

The ratio of diseased leaves was rather high in all plots, especially in plots with more than 1 N. Degree of disease development was low in the 0 to 1/4 N plots, and uniformly high in the 1/2 to 5 N plots (Table 3). A significant correlation between total nitrogen content in 3rd, 7th and 11th position leaves and the ratio of diseased leaves was not recognized. However,

Table 1. Total nitrogen and total carbon content in Japanese pear cv. Chojuro leaves from trees given different amounts of nitrogen fertilizer

| Level of nitrogen applied[a] | Total nitrogen concentration[b] | | | Total carbon concentration | | |
|---|---|---|---|---|---|---|
| | 3[c] | 7 | 11 | 3 | 7 | 11 |
| 1 N | 1.71% | 1.88% | 1.83% | 45.7% | 45.2% | 45.3% |
| 1/4 N | 2.26 | 2.57 | 2.43 | 45.4 | 45.2 | 45.6 |
| 1/2 N | 2.87 | 3.27 | 3.20 | 45.9 | 45.4 | 45.1 |
| 1 N | 3.12 | 3.23 | 2.88 | 46.7 | 46.0 | 45.8 |
| 2 N | 2.83 | 3.12 | 2.78 | 46.6 | 45.8 | 45.8 |
| 3 N | 3.21 | 3.08 | 3.28 | 46.4 | 45.2 | 45.9 |
| 4 N | 2.81 | 3.35 | 3.29 | 46.4 | 46.0 | 46.0 |
| 5 N | 3.12 | 3.54 | 3.88 | 46.3 | 46.2 | 47.0 |
| Orchard[d] | 2.68 | 2.69 | 2.69 | 46.5 | 46.0 | 45.3 |

a) Amount of nitrogen fertilizer applied in plot 1 N is 200 kg-N/ha with ammonium sulfate.
b) % of dry weight.
c) Leaf position from top marked leaf.
d) Trees in orchard applied standard level of nitrogen fertilizer (1 N).

Table 2. The contents of some nutrient elements in leaves of Japanese pear cv. Chojuro trees applied with different amounts of nitrogen fertilizer

| Level of nitrogen applied[a] | P (%) | | K (%) | | Ca (%) | | Mg (%) | | Fe(ppm) | | Mn(ppm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7[b] | 11 | 7 | 11 | 7 | 11 | 7 | 11 | 7 | 11 | 7 | 11 |
| 0 N | 0.18 | 0.15 | 1.97 | 1.71 | 1.08 | 1.09 | 0.27 | 0.23 | 132 | 192 | 37.9 | 37.8 |
| 1/4N | 0.25 | 0.19 | 2.19 | 1.92 | 0.93 | 1.16 | 0.28 | 0.25 | 71 | 216 | 39.7 | 46.1 |
| 1/2N | 0.34 | 0.26 | 2.46 | 2.33 | 0.75 | 0.96 | 0.30 | 0.26 | 126 | 160 | 43.6 | 42.0 |
| 1 N | 0.27 | 0.19 | 2.29 | 2.04 | 0.85 | 1.18 | 0.25 | 0.25 | 120 | 151 | 52.1 | 64.7 |
| 2 N | 0.26 | 0.18 | 2.33 | 2.11 | 0.80 | 1.00 | 0.27 | 0.24 | 104 | 207 | 56.5 | 63.4 |
| 3 N | 0.23 | 0.17 | 2.40 | 1.93 | 0.78 | 1.12 | 0.27 | 0.29 | 105 | 180 | 67.0 | 75.4 |
| 4 N | 0.24 | 0.17 | 1.88 | 1.78 | 0.84 | 0.99 | 0.25 | 0.27 | 181 | 199 | 69.2 | 71.4 |
| 5 N | 0.22 | 0.18 | 1.70 | 1.63 | 0.76 | 0.65 | 0.29 | 0.29 | 97 | 163 | 66.1 | 62.3 |
| Orchard[c] | 0.22 | 0.20 | 1.17 | 1.04 | 1.15 | 1.78 | 0.29 | 0.34 | 109 | 84 | 50.9 | 76.3 |

a), b) and c) See Table 1.

Table 3. Scab development on Japanese pear leaves from trees given different amounts of nitrogen fertilizer

| Level of nitrogen applied[a] | No. of leaves | Ratio of diseased observed leaves | Degree of disease development | Degree of conidia formation |
|---|---|---|---|---|
| 0 N | 67 | 49.3(%) | 39.9 | 4.5 |
| 1/4N | 56 | 50.0 | 38.8 | 8.0 |
| 1/2N | 69 | 50.7 | 71.0 | 6.9 |
| 1 N | 69 | 89.9 | 71.0 | 24.6 |
| 2 N | 69 | 81.2 | 64.9 | 22.8 |
| 3 N | 67 | 62.7 | 51.9 | 18.7 |
| 4 N | 56 | 73.2 | 57.6 | 19.2 |
| 5 N | 42 | 92.9 | 70.2 | 41.1 |

a) See Table 1.

Table 4. Correlation between nutrient element content in leaves of Japanese pear trees and disease development and conidia formation

| Nutrient element | Leaf position | Ratio of diseased leaves | Degree of disease development | Degree of conidia formation |
|---|---|---|---|---|
| Total nitrogen | 3 | 0.665 | 0.765*[a] | 0.684 |
| | 7 | 0.670 | 0.830* | 0.700 |
| | 11 | 0.575 | 0.693 | 0.745* |
| Calcium | 7 | −0.472 | −0.772* | −0.559 |
| | 11 | −0.438 | −0.494 | −0.647 |
| Manganese | 7 | 0.647 | 0.406 | 0.734* |
| | 11 | 0.658 | 0.341 | 0.651 |

a)* Significant correlations are recognized in these coefficient of correlation ($P$=0.05).

there was a significant correlation ($P$=5%) between total nitrogen content in 3rd and 7th position leaves and the degree of diseased development and that in 11th position leaf and degree of conidial formation (Table 4). On the other hand, the total carbon concentration in all leaf samples was about 45% of the dry weight and the relationship between total carbon content at each position leaves and ratio of diseased leaves, degree of disease development and degree of conidial formation were not clearly recognizable (Table 1).

***The correlation between the ratio of diseased leaves, degree of disease development and degree of conidial formation and leaf content of other elements***

A significant negative correlation ($P=5\%$) between calcium content in leaves and the degree of disease development was recognized (Table 4). There was also a significant correlation ($P=5\%$) between the manganese content in 7th position leaf and the degree of conidial formation. Although there was no significant correlation, there appeared to be close relationship between the manganese content in 11th position leaf and the ratio of diseased leaves ($r=0.658$), and the degree of conidial formation ($r=0.651$) (Table 4). On the other hand, no significant correlations were recognized between the ratio of diseased leaves, degree of disease development and degree of conidial formation and the content of other elements in leaves.

## DISCUSSION

This study was conducted to clarify the relationship between Japanese pear scab development and the application of different amounts of nitrogen fertilizer. The results indicated that application of excessive nitrogen fertilizer was directly correlated to the increasing in ratio of diseased leaves, degree of disease development and conidial formation. A significant correlation ($P=5\%$), especially between total nitrogen content at 3rd and 7th position leaves and degree of disease development, was recognized at Table 4. Total nitrogen content in 7th position leaf between high and low degrees of disease development on leaves was between 1/4 and 1/2 N plots and their total nitrogen concentrations were 2.57 and 3.27%, respectively. Total nitrogen concentration in 7th position leaf of cv. Chojuro in the Fruit Trees Lab. orchard as control plot was 2.69%. This value was thought to be a middle value between high and low degrees of disease development obtained in this study. In spite of given different amounts of nitrogen fertilizer, the total nitrogen content in leaves of the same position were almost the same for grafted trees in this study and adult orchard trees. It appears, therefore, that the grafted trees grown in pots can take up nitrogen fertilizer at a higher ratio than adult trees grown in the orchard. If the ratio of nitrogen uptake is about the same among rootstocks grafted Japanese pear cultivars when grown in Humic Andosols soil in the Fruit Trees Lab. orchard, 200 kg of nitrogen per 1 ha applied as nitrogen fertilizer seems to be at the upper limits for maintaining a low level of disease development. When plant tissues contain high levels of nitrogen elements, it is said that they generally become tender and susceptible to many kinds of disease. This tendency was also confirmed for Japanese pear scab by the results of this study.

On the other hand, there was no significant correlation between total carbon content and the ratio of diseased leaves, degree of disease development or conidial formation. The reason was thought to be because there was a constant carbon concentration of about 45% of dry weight in all plots, regardless of different amounts of nitrogen fertilizer.

For the other elements, the significant negative correlation ($P=5\%$) between calcium content in 7th position leaf and the degree of disease development was recognized (Table 4). The major reason for this was considered to be that tissues having a high content of calcium became hard[4] and were unfavorable for infection and lesion formation for the Japanese pear scab fungus. A significant correlation ($P=5\%$) between manganese content in 7th position leaf and the degree of conidial formation was also recognized (Table 4). The major reason for this was considered to be that increase in manganese content were closely related to increases in the total nitrogen content and nitrogen metabolism[9].

The results of this study show that when large amounts of nitrogen are applied to Japanese pear trees, the total nitrogen and manganese contents in leaves becomes high and, conversely, the calcium content becomes low and scab disease become more severe.

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## 和 文 摘 要


梅本清作：ニホンナシに対する窒素肥料の施用量の違いによる葉中の成分濃度および黒星病の発病程度

窒素肥料の施用量に伴う葉中の各種成分濃度とニホンナシ黒星病の発生程度との関係について検討した。その結果，窒素肥料の施用量の増加に伴い葉中の全窒素，マンガン濃度は漸増し，カルシウムは漸減し，病葉率，発病度および分生子形成度はいずれも高まる傾向が認められた。しかし，全炭素，リン，カリウム，マグネシウムおよび鉄の濃度にはほとんど変化がみられなかった。また，葉中の全窒素濃度と病葉率との間には相関は認められなかったが，第 3 および 7 葉位の発病度および第 11 葉位の分生子形成度との間には有意な相関 ($P=0.05$) が認められた。また，第 7 葉位の発病度とカルシウム濃度との間および第 7 葉位の分生子形成度とマンガン濃度との間にも同様に有意な相関が認められた。以上から，窒素肥料の施用量の増加に伴い，葉中の全窒素濃度およびマンガン濃度が増加し，逆にカルシウム濃度は減少し，黒星病の発生は激しくなることが明らかとなった。