Abnormal Defoliation of Satsuma Mandarin Trees

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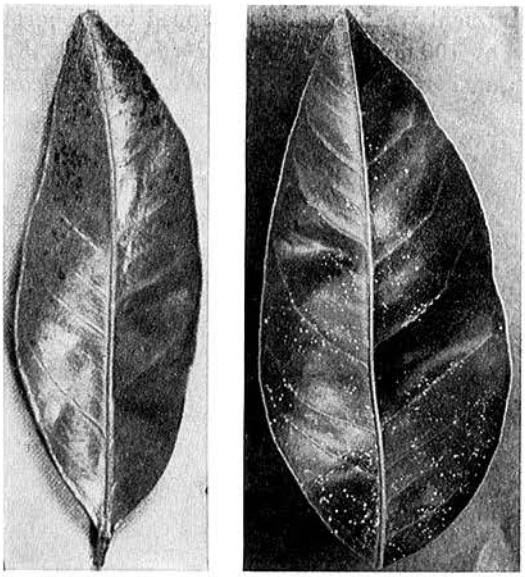
Around 1955, it was noticed in some Satsuma mandarin orchards of some prefectures that trees show spotting of leaves followed by abnormal defoliation from autumn to winter and the cause is unknown.

This abnormal defoliation has so widely spread since about 1960 that it is seen in most Satsuma mandarin growing prefectures and has become an important problem in the cultivation of Satsuma mandarin trees.

Under these circumstances, the main fruit tree experimental stations of Satsuma mandarin growing prefectures cooperated to solve the problem for 8 years from 1961 to 1968 and obtained many noticeable results.

I also have been studying the abnormal defoliation since 1961 from the viewpoint of the abnormal absorption of minor metallic elements by Satsuma mandarin trees and obtained the results, an outline of which is dealt with in this paper.



Large red-brown spot | Small light-brown spot

Fig. 1. Typical symptoms of spotted leaves by abnormal defoliation

Symptoms of abnormal defoliation and the period of their development

The trees affected by the abnormal defoliation show two kinds of leaf-spot symptoms—large reddish brown spots and small brown spots. The large reddish brown spots are 2–5 mm in diameter and chocolate in color. They have the appearance of indistinctly outlined yellow spots when observed from the lower surface of the leaves. The small brown spots are 0.2–0.3 mm in diameter. They are concavity spots, which show a necrosis of leaf tissues reaching to the lower surface of the leaves when spots was matured.

The development of leaf spots usually begins in a period from September to December and reaches the peak from December to April and comes to an end between April and May.

Defoliation is noticeable from January to March. The Satsuma mandarin trees affected by the abnormal defoliation were observed to be less vigorous and less fruitful as compared with normal trees. They were poor in the

growth of new roots and had many decayed rootlets. It was noticed from an investigation carried out in 1961 that abnormal defoliation tended to prevail in the orchards to which a large amount of fertilizer was applied.

Analysis of leaves and rootlets collected from affected trees

Leaves and rootlets were collected from Satsuma mandarin trees in 13 prefectures as shown in Fig. 2 and analyzed chemically.

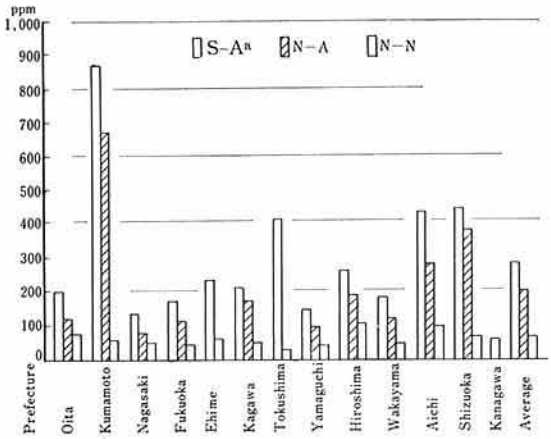


Fig. 2. Comparison of average manganese content in leaves in each prefecture
S-A...Spotted leaves of abnormal defoliated trees
N-A...Normal leaves of abnormal defoliated trees
N-N...Normal leaves of normal trees

Every sample of the normal leaves of normal mandarin trees (N-N) thus examined showed a manganese content of not more than 100 ppm (Fig. 2) while the spotted leaves of mandarin trees affected by abnormal defoliation (S-A) were 100 ppm or more in manganese content, showing a distinct difference of manganese content between both kinds of leaves.

The normal leaves of affected trees (N-A) were lower in manganese content than the spotted leaves of the trees, but considerably higher than the normal leaves of normal trees (N-N).

The contents of other 17 elements than manganese were also determined in those leaves and the ratios of each element contents of the spotted leaves or normal leaves of abnormal defoliated trees to the contents of the normal leaves of normal trees are shown in Fig. 3.

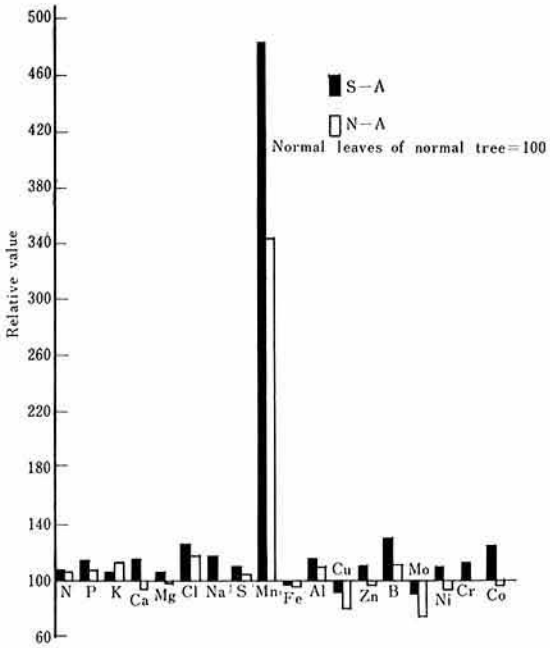


Fig. 3. Comparison of various element contents in leaves

There was a marked difference of manganese content between normal and spotted leaves but the contents of the other elements showed no great difference between both kinds of leaves except that the chloride, sodium, boron and cobalt contents had a tendency to be a little higher in spotted leaves than in normal ones.

As shown in Fig. 4, the manganese content of the rootlets was remarkably higher in affected trees than in normal ones in the four prefectures of Kumamoto, Shizuoka, Kanagawa and Tokushima while the content showed little difference between normal and affected trees in the other prefectures.

In Oita and Nagasaki prefectures, the manganese contents of the rootlets from both normal and affected trees were markedly lower than in the other prefectures.

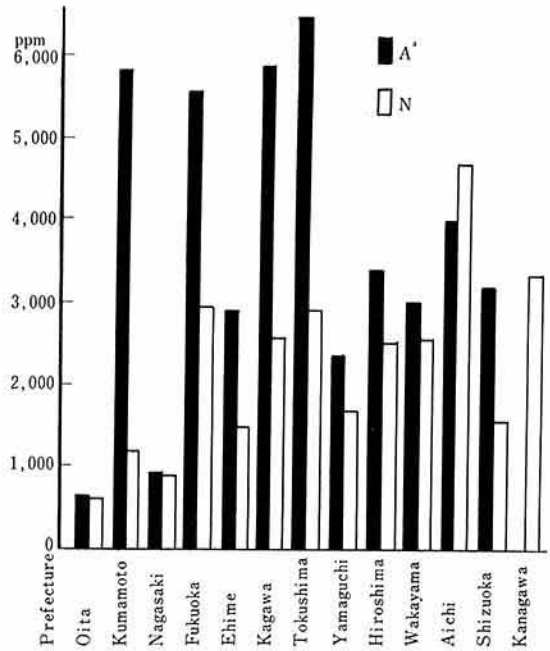


Fig. 4. Manganese content ot rootlet in each prefecture
A^{a}...Abnormal defoliated trees
N...Normal trees

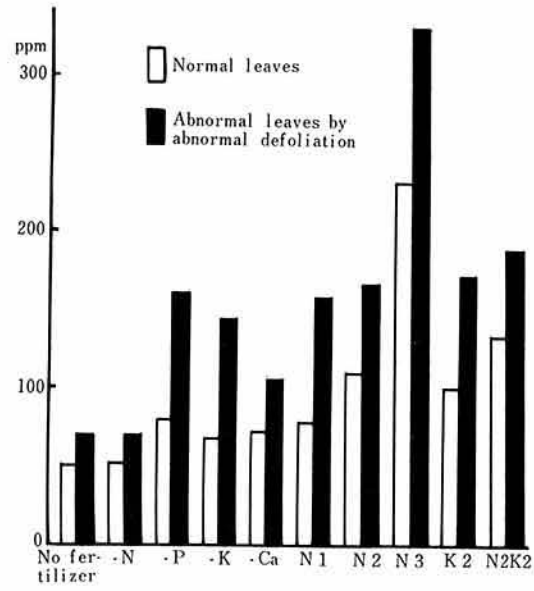


Fig. 5. Manganese content in leaves (average of 4 years)

Influence of the application of fertilizer on the development of abnormal defoliation and the absorption of minor metallic elements by Satsuma mandarin trees

In order to carry out this study, the experimental orchard of Kunisaki Citrus Guidance Station, Oita Prefecture, was used for the four elements fertilizer experiment. Study was made in the relation between the amount of fertilizer applied and both the development of spotted leaves and the absorption of minor metallic elements by Satsuma mandarin trees.

Ten experimental plots were designed as shown in Fig. 5. The amount of fertilizers applied to each plot were as followers: N 10 kg, P_2O_5 8 kg, K_2O 9 kg and CaO 100 kg per 10 a in plot N 1 (standard); the amount of N

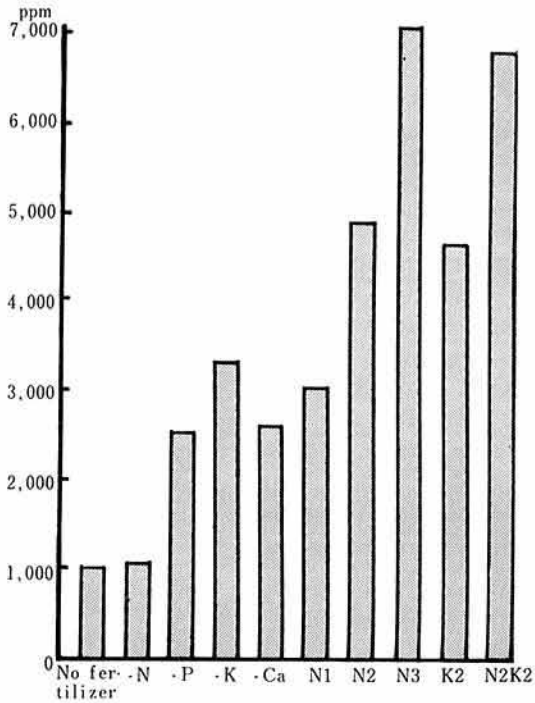


Fig. 6. Manganese content in rootlet (average of 4 years)

was increased to two times and three times the amount applied to N 1 in N 2 and N 3, respectively; the amount of K_2O was increased to two times the amount applied to N 1 in K 2.

The development of spotted leaves increased with the amounts of N and K_2O applied while it was scarcely observed in the plots of both no fertilizer and –N. Fruit production was high in N 1 and –N and low in N 3 and N2K2.

The manganese contents of both spotted and normal leaves were remarkably low in –N and noticeably high in N 3 (Fig. 5).

The manganese content of rootlets was strikingly low in the plots of both no fertilizer and –N, and remarkably high in N 3 and N2K2 followed by N 2 and K 2 (Fig. 6).

The water soluble manganese content of the soil was the highest in N 3 followed by N 2, K 2 and N2K2, being very low in the plots of both no fertilizer and –N (Fig. 7). The water soluble aluminum content of the soil had nearly the same tendency of variation as the manganese content but very low in concentration (Fig. 7).

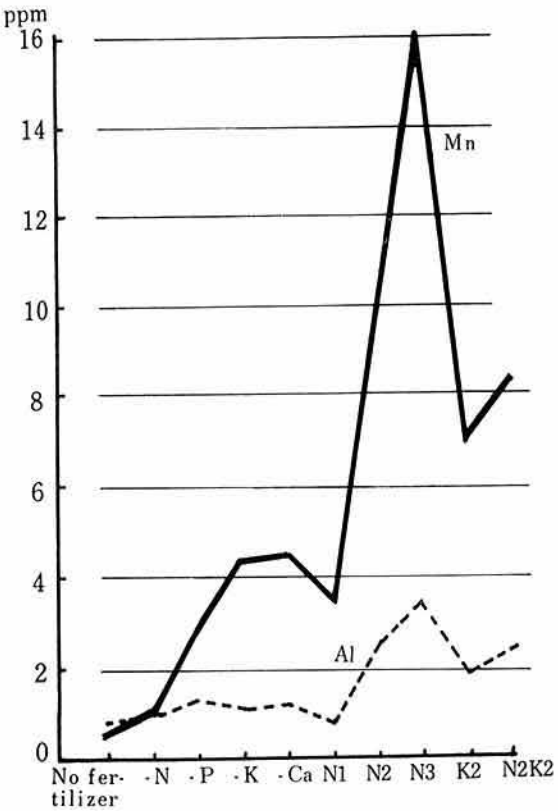


Fig. 7. Water soluble manganese and aluminum contents in soil (average of 4 years)

The correlation between the manganese content of the leaves and the water soluble manganese content of the soil was very high (positive) as shown in Fig. 8.

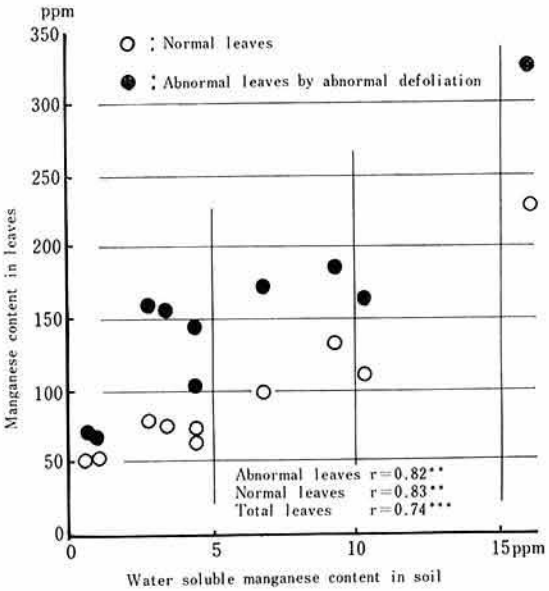


Fig. 8. Correlation between manganese content in leaves and water soluble manganese content in soil (average of 4 years)

Similar correlation was also observed between the following contents: the manganese content of the leaves and that of the rootlets; the manganese content of the leaves and the 1 N ammonium acetate soluble manganese content of the soil; the manganese content of the rootlets and the water soluble manganese content of the soil; the manganese content of the rootlets and the 1 N ammonium acetate soluble manganese content of the soil. Highly negative correlation was observed between the manganese content of the leaves or rootlets and the pH of the soil.

Influences of heavy metallic salts applied, fruiting and rootstocks on the development of abnormal defoliation and the absorption of minor metallic elements by Satsuma mandarin trees

The following facts were made clear:

(1) Manganese is more easily absorbed by Satsuma mandarin trees than aluminum, copper, zinc and nickel.

(2) Satsuma mandarin trees develop symptoms similar to the abnormal defoliation when manganese is applied to them but they do not show such defoliation when other metallic salts are applied.

(3) The trees tend to show abnormal defoliation when they have heavy bearing.

(4) Satsuma mandarin trees grafted on trifoliate orange rootstocks have a tendency to be more easily affected by abnormal defoliation as compared with the trees grafted on Junos rootstocks.

Conclusion

I have made a study of the development of an abnormal defoliation accompanied with leaf spotting in Satsuma mandarin trees to clarify the cause of the disorder of mandarin trees and considered how to prevent defoliation, making the following facts clear:

(1) The manganese content of spotted leaves is remarkably higher than that of normal leaves.

(2) The soil becomes acidic and the absorption of manganese by Satsuma mandarin trees as well as the development of leaf spots increases as the application of fertilizers increases in amount.

(3) The development of leaf spots can be directly induced by the application of manganese to the trees.

(4) The mechanism of the development of leaf spots has not yet been made clear but it is necessary to apply a reduced amount of fertilizers and correct the acidity of the soil to prevent Satsuma mandarin trees from abnormal defoliation. In Japan, most of the citrus orchards affected by abnormal defoliation have been almost saved by these treatments.

References

1) Ishihara, M. et al.: Studies on abnormal defoliation of Satsuma mandarin trees. *Bull. Hort. Res. Sta., Japan*, Ser. A. No. 10, 55-180 (1971).

I. Investigation on abnormal defoliation in Satsuma mandarin orchards and their leaf and root analysis.

II. The effect of fertilizer application on the development of abnormal defoliation and on the absorption of minor metal elements of Satsuma mandarin trees.

III. The influence of excessive soil application of manganese, aluminium, copper, zinc and nickel on the development of abnormal defoliation and on the absorption of minor metal elements of Satsuma mandarin trees.

IV. The influence of fruiting and of rootstocks on the development of abnormal defoliation and on the absorption of minor metal elements of Satsuma mandarin trees.