Leaf Analysis as a Guide to Nitrogenous Fertilizer Application in Satsuma Mandarin Orange Orchards

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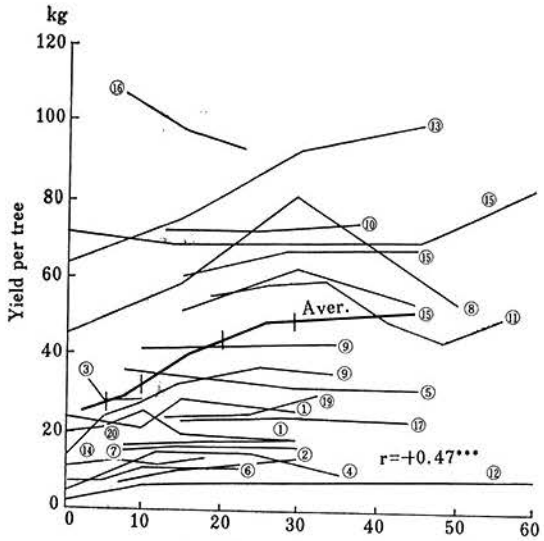
In many prefectures of Japan, nitrogenous fertilizer application experiments have been carried out with Satsuma mandarin orange orchards in recent years. Data obtained in some prefectural experiment stations (listed in Fig. 1) were examined in relation to the leaf analysis. The result is reported in this paper.



Data from the following prefectural experiment stations:

1) Kagoshima	6,7,20) Saga	12) Hiroshima
2) Miyazaki	8) Kumamoto	13,14) Ehime
3, 4) Oita	9,10) Nagasaki	15,16) Mie
5) Fukuoka	11) Yamaguchi	17) Shizuoka

Fig. 1. Relation between amount of nitrogen applied and fruit yield

Effect of applied nitrogen on yields

As given in Fig. 1, yields of Satsuma mandarin orange were generally increased to a certain level by nitrogen application, but more nitrogen application tends to decrease the yields. In an average, nitrogen application up to 30 kg/10a apparently increased the yields, but more nitrogen gave only a very slight increase of yields.

Rates of nitrogen application in high-yielded plots

Rates of nitrogen applied in high-yielded plots in each prefectural experiment station are shown in Table 1. The rate of 20–30 kg N/10a was highest in frequency, followed by 10–20 kg N, and the rates more than 30 kg N or less than 10 kg N were of low frequency. The rates were different with different soil types: 15.8 kg N for volcanic ash soils and 26.9 kg N for granite soils, indicating that the optimum rate of nitrogen application depends on soil types. Generally, it can be said that the upper limit of nitrogen application seems to be about 30 kg N/10a.

Table 1. Distribution of rate of nitrogen applied to high-yielded plots in nitrogen fertilization experiments conducted in prefectural experiment stations

Amount of nitrogen applied (kg per 10a)	0—10. 0	10. 1—20. 0	20. 1—30. 0	30. 1—
Distribution (%)	19. 0	23. 8	38. 2	19. 0

Effect of applied nitrogen on N content of leaves

Relationship between rates of nitrogen application and N content of leaves (the lowest content at about September in recent 5 years) determined in each experimental orchard is given in Fig. 2, which shows a highly signifi-

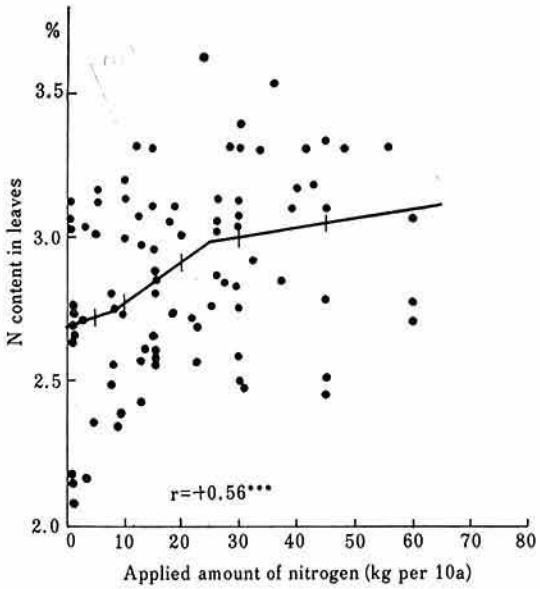


Fig. 2. Relation between amount of nitrogen applied and N content of leaves of Satsuma mandarin orange

cant correlation, $r=+0.56$.** In an average, N content of leaves was increased apparently by nitrogen application when N content of leaves was lower than approximately 3% (grown without nitrogen applied or with low rates of application) whereas no appreciable increase occurred when N content of leaves was higher than 3%.

N content of leaves and yield response to nitrogen applied

Yield response to nitrogen application was determined by expressing the yields of highest yielded plots in percentage of yields of the plots without or with small amount of nitrogen

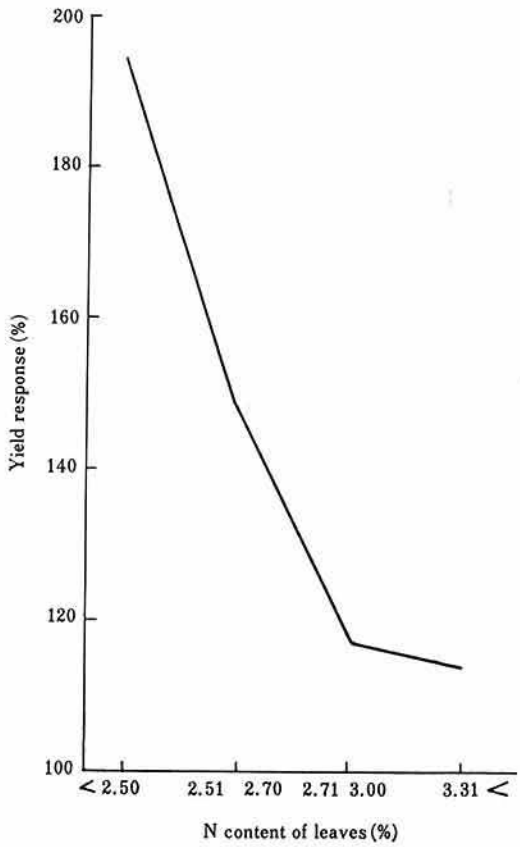


Fig. 3. Yield response to nitrogen application as related to N content of leaves before the application

applied, taken the latter as 100, as shown in Fig. 3. Yield response was remarkable when N content of leaves was lower than 2.5% or even 2.51–2.70%, but it was very small with trees showing N content higher than 2.71%. It was observed in another study, that yields tended to decrease when N content of leaves increased more than 3.3%. Therefore, the optimum N content of leaves for obtaining higher yields is considered to be approximately 2.7–3.3%.

Relationship between N content of leaves and fruit quality

For N content of leaves, the lowest value obtained in 5 years was used, and the fruit quality was an average of 5 years.

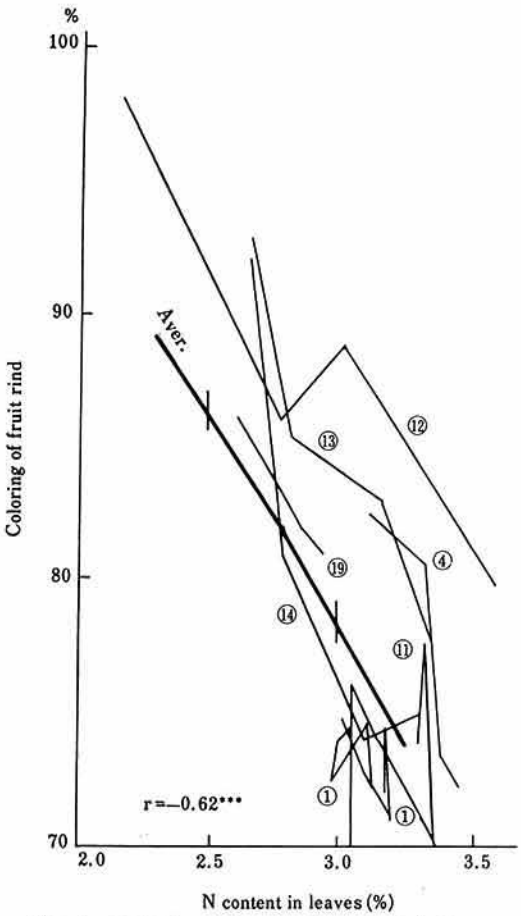


Fig. 4. Relation between N content in leaves and coloring of fruit rind in Satsuma mandarin orange

1) Coloring of fruit rind

With the increase of N content of leaves the color development became apparently poor (significant at 0.1% level), as given in Fig. 4.

2) Rate of fruit rind

As shown in Fig. 5, rate of fruit rind increased (fruit rind became thick) with the increase of N content of leaves (significant at 0.1% level).

3) Specific gravity of fruit

As shown in Fig. 6, specific gravity of fruit decreased with the increase of N content of leaves up to 3%, but beyond that no more decrease occurred (significant at 0.1% level).

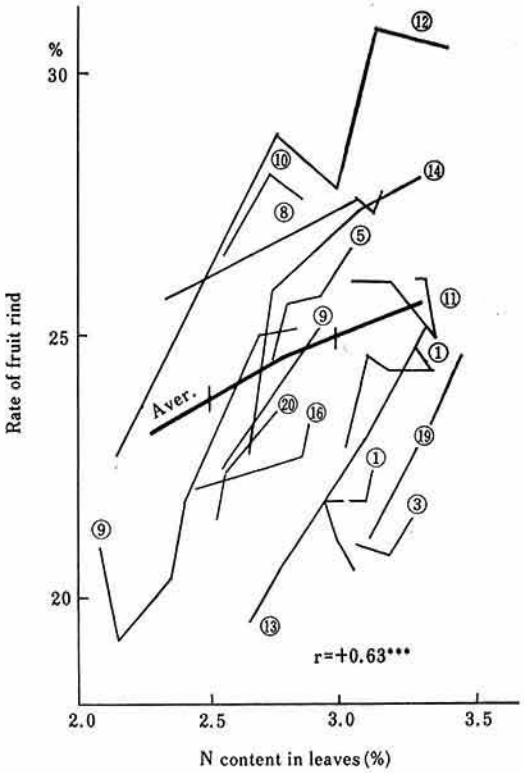


Fig. 5. Relation between N content in leaves and rate of fruit rind

4) Free acid content of fruit juice

As shown in Fig. 7, no definite correlation was found between N content of leaves and free acid content (in terms of citric acid) of fruit juice. However, the tendency was that free acid content was higher with N content lower than 2.5% or higher than 3.2%.

5) Sugar content of fruit juice

No definite relationship was observed between N content of leaves and sugar content of fruit juice, as indicated by total sugars, reading of refractometer, total soluble solid, or Brix values.

6) Ratio of sugar/acid in fruit juice

As given in Fig. 8, relation of the ratio to N content of leaves was reverse to that of free acid content. The ratio showed a tendency to be low with N content lower than 2.5% or higher than 3.3%.

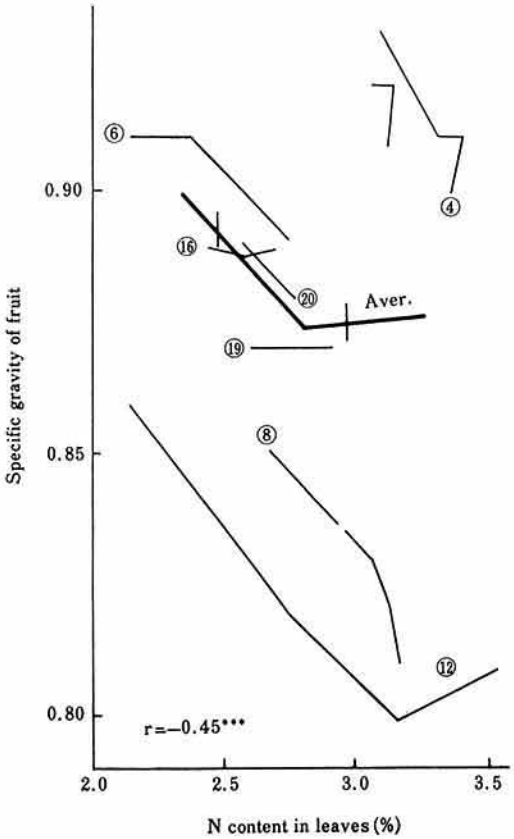


Fig. 6. Relation between N content in leaves and specific gravity of fruit

Conclusion

The results obtained in this study are illustrated in Fig. 9 in a manner similar to the schema of Jones et al. (1968b) and Embleton et al. (1973). By takin into consideration all together the yearly variation of yields and fruit quality, and that lowest values of N content of leaves in 5 years was utilized for this study, it can be concluded tentatively at the present moment that the optimum N content of leaves seems to be about 2.8–3.0%. This value is consistent with the standard content shown by Satō et al. (1952 and 1954).

Jones et al. (1968a) reported that optimum N content of orange leaves was 2.6%, and in case when the content was higher than 2.7% no nitrogen was applied until the content decreased to 2.6%, whereas in case of N content lower than 2.5%, the lower the content,

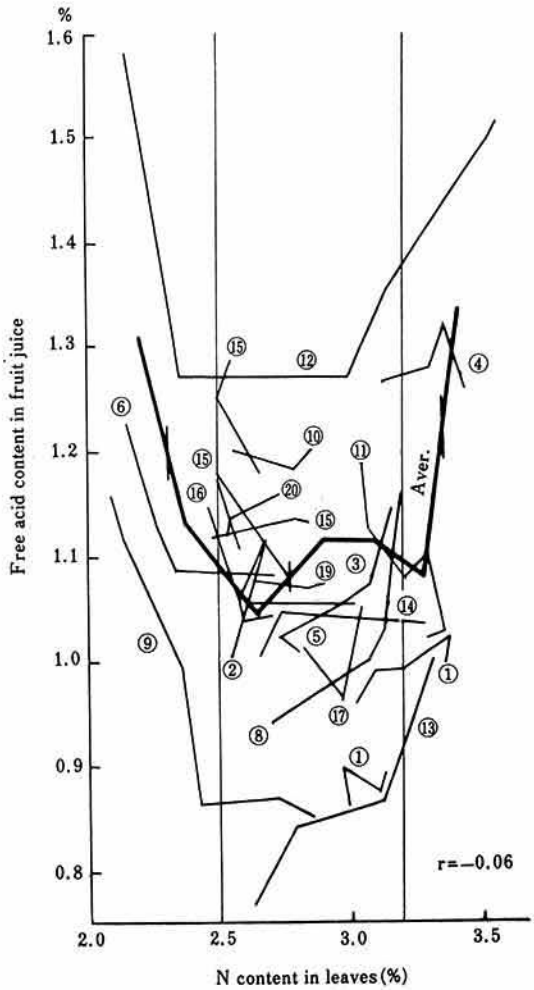


Fig. 7. Relation between N content in leaves and free acid (as citric acid) content in fruit juice

the more fertilization was made. In addition, several other studies on leaf analysis as a guide to fertilization were reported (see references).

Further problems are (1) nitrogenous fertilizer application experiments are desired to be carried out with different soils separately, and (2) it is desirable to take up leaf analysis study as a guide to determine the rate of nitrogen application in Japan, particularly it is necessary to determine to what extent nitrogen can be saved in the orchards with N content of leaves higher than 3%. Thus the optimum N content of leaves will be de-

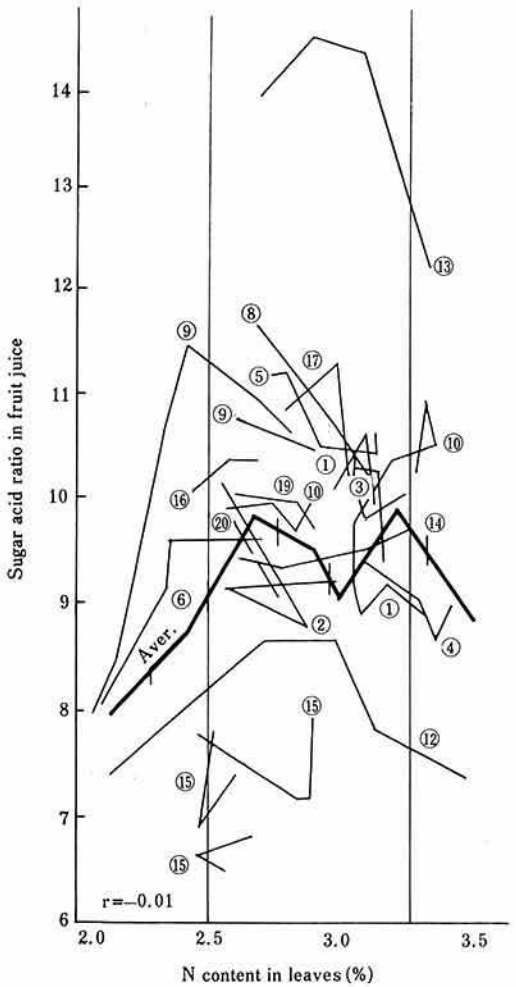


Fig. 8. Relation between N content in leaves and sugar acid ratio in fruit juice

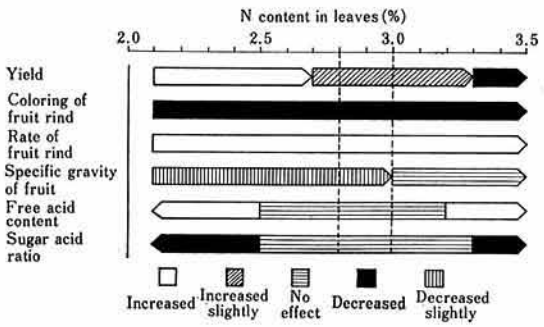


Fig. 9. Relation between N content in leaves and yield or fruit quality in Satsuma mandarin orange (1975)
---- Optimum range (tentative value)

termined more definitely.

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