



Relationships between Soil Characteristics and Brewing Grape Quality in Katsunuma, Yamanashi Prefecture, Japan

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Abstract In this study, the qualities of Chardonnay grapes from Katsunuma, Yamanashi Prefecture used for making wine, in, and the physical and chemical properties of the soils around the target fruit trees were analyzed to define the relationships between the grapes and soil properties. The survey covered three garden sites from one winery in Katsunuma Town. Undisturbed soil and disturbed soils were sampled from a depth of 20 cm, 30 cm below the trunk of the vines, and were used to measure physical and chemical properties, respectively. The physical properties measured were three-phase distribution, soil particle size composition, and hydraulic conductivity. Chemical properties measured were pH, EC, K₂O, Na₂O, CaO, and NO₃-N. Grapes were collected at harvest time, de-stemmed and pressed, and then analyzed for sugar content, glucose, fructose, acidity, malic acid, and tartaric acid. Software R was used for statistical analysis. The experimental results indicate that differences in soil particle size composition and soil properties may affect the sugar and acid levels of the grapes. In addition, soil pH, permeability, and CaO were found to be important factors to be considered in wine making. Soil pH has a strong correlation with glucose, grape pH, and sugar content, and may serve as an indicator when evaluating soil pH in the future. In summary, it was clear that soil physical and chemical properties affect fruit quality.

Keywords vineyard, wine, terroir, vinification grapes, soil pH, Yamanashi

INTRODUCTION

Wine production in Japan began in 1870, when the Meiji government added measures to promote grape cultivation and winemaking as part of its industrial development policy. However, wine making failed and ended in 1890s, because the wine's acidity did not suit the Japanese taste. In 1918, various brewing companies succeeded in marketing sweet wines that suited Japanese tastes. The number of wines consumed in Japan has changed dramatically since then, with the first wine boom in 1972, followed by a seventh boom in 2020. In the process, consumers have become more knowledgeable about wine and have a better understanding of its taste and culture.

The number of domestically produced wines continued to increase and to a 2018 policy regarding, strict labeling standards for Japanese wines was established, requiring that at least 85% of the grapes used in a wine must be from that region and vinified in that region to be labeled with the wine's origin name, raising expectations that quality grapes are fully available in each wine-growing region. On the producer's side, it is also necessary to produce high quality wine in Japan for surviving at the international market.

There is a recognition that to produce quality wine, quality grapes must be grown. In other words, terroir is important as it directly affects the properties of wine.

What is required for vinification grapes is a fruit with a higher concentration of sugar and aroma components than grapes eaten for fresh consumption, and although various theories are

known about the physicochemical properties of the garden soil that produces such excellent fruit (Miura et al., 2020), there is insufficient scientific verification. In addition, there have been very few studies on vineyard soils in Japan compared to those in Europe and the United States, and the soil environmental conditions suitable for cultivation of grapes for vinification in the Japanese climate have not been clarified.

OBJECTIVE

Given the above background, understanding the influence of soil's physical and chemical properties on oenological grape quality is essential for improving wine quality. Accordingly, the objectives of this study were to evaluate the physical and chemical properties of Chardonnay, a white wine grape variety grown in Katsunuma, Yamanashi Prefecture, and to clarify its relationship with soil physical and chemical properties and fruit quality.

METHODOLOGY

In this experiment, 3 vineyard sites which grow Chardonnay grape varieties were surveyed: In Site 1, grapes were grown as a hedge cultivar and the soil group was lowland soil, in Site 2, grapes were shelf grown and the soil group was also lowland soil, and in Site 3, grapes were hedge grown and the soil group was brown forest soil (Figs. 1 to 3).



Fig. 1 Vineyard site 1



Fig. 2 Vineyard site 2



Fig. 3 Vineyard

Soil Sampling

Approximately 300 g of undisturbed and disturbed soil was collected at 27 locations in each garden in July, using a 100 ml core sampler can from a depth of 20 cm, 30 cm or less below the tree trunk.

Soil Measurements

Physical properties of undisturbed soil were measured by three-phase distribution, particle size composition (hydrometer method), and permeability (hydraulic conductivity test). Chemical properties were measured using disturbed soil after passing the soil through a 2 mm sieve. Chemical properties were measured using a HORIBA compact ion meter.

Juice Components

The grapes were de-stemmed, crushed, and pressed before being made into juice as a pretreatment for juice component analysis. Items measured were sugar content, glucose, fructose, acidity, tartaric acid, and malic acid (Humitsuki, 2006; Nakayama, 1993).

Statistical Analysis

Statistical software R was used for statistical analysis between soils, and multiple comparison analysis was performed. T-tests were performed in Excel for soil and grape components.

RESULTS AND DISCUSSION

Soil pH showed a strong positive correlation with glucose, a grape component, and grape pH and sugar content. This indicates that soil pH is closely related to the major grape juice components. The soil pH in this study was lower than the gardener's target value, so it is necessary to consider how to improve soil pH in the future.

The hydraulic conductivity was strongly correlated with sugar content. Previous studies have generally agreed that grapes produced under moderate moisture stress produce wines with superior sugar and aroma (Van Leeuwen et al., 2009; Feiring and Lepeltier, 2017). Because of Japan's humid climate with high rainfall, well-drained soils are considered important for the production of quality vinification grapes (Saito et al., 2017). In this study, the permeability in the soil was good in the range of 10^{-3} ~ 10^{-4} and did not differ significantly among the orchard sites, which is attributed to the high sugar content of the grapes due to the excellent permeability of the soil in the target sites. This suggests that the sugar content is highest when the soil is subjected to moderate moisture stress.

The concentration of CaO was strongly correlated with malic acid. Malic acid is found in many organisms, not only grapes. Malic acid and tartaric acid are the major organic acids in wine and, depending on the degree of ripeness, have a significant impact on the acidity quality of wine. Concentrations range from 100 to 200 (mg/L) in warmer areas, but are relatively low at 15 to 30 (mg/L) in target areas. We believe that lime application is also effective for soil pH in order to improve CaO in the soil.

Table 1 Correlation coefficient and confident interval

	Permeability	EC	Soil pH	K ₂ O	CaO	Na ₂ O	NO ₃ -N
Brix (%)	0.88**	-0.70	0.98*	-0.22	0.82	0.06	-0.30
Glucose (%)	0.55	-0.93	0.98*	-0.59	0.52	-0.34	0.11
Fructose (%)	-0.92	-0.92	-0.77	0.24	-0.08	0.73	-0.54
Grape pH	0.96	-0.84	0.99*	-0.43	0.68	-0.16	-0.08
Acidity (%)	0.97	-0.61	0.99	-0.11	0.65	-0.19	-0.04
Malic acid	0.38	0.34	0.62	0.78	0.98**	0.72	-0.87
Tartaric acid	0.97	-0.61	0.99	-0.11	0.65	-0.19	-0.04

Notes: n=27, *: 95% confidence interval, **: 99% confidence interval

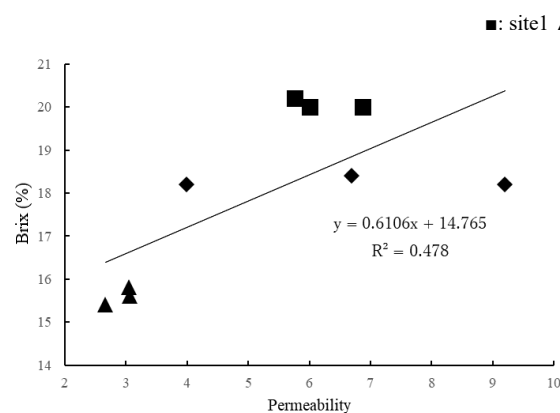


Fig. 4 Correlation between hydraulic conductivity and sugar content

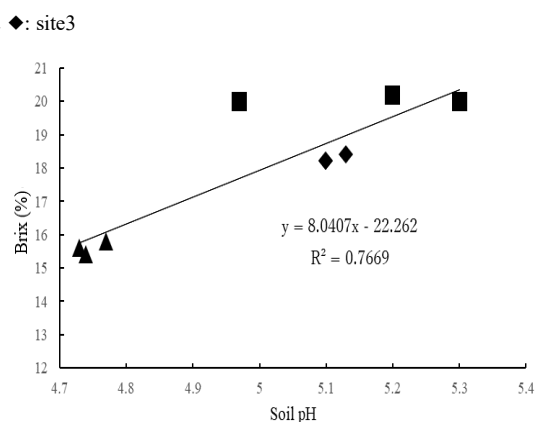


Fig. 5 Correlation between soil pH and sugar content

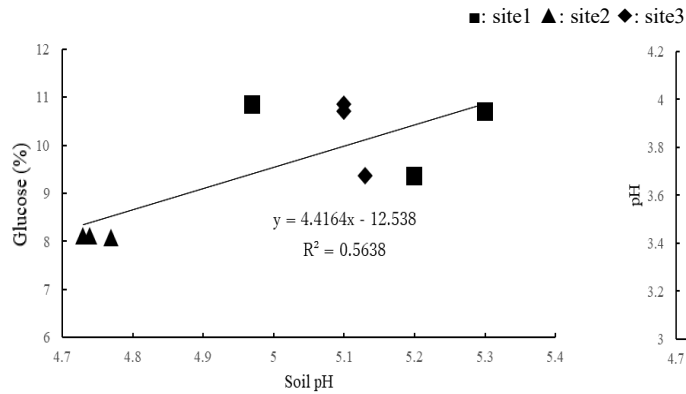


Fig. 6 Correlation between soil pH and glucose

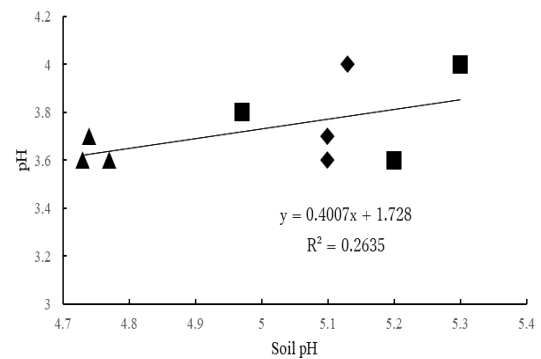


Fig. 7 Correlation between soil pH and grape pH

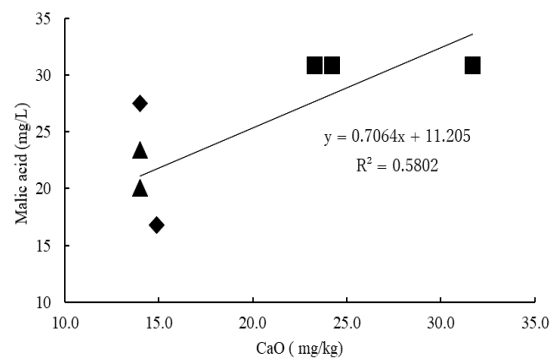


Fig. 8 Correlation between calcium oxide and malic acid

CONCLUSION

Soil pH, permeability, and CaO were found to be important factors to watch in winemaking. Especially, soil pH has a strong correlation with glucose, grape pH, and sugar content, and may serve as an indicator when evaluating soil pH in the future. The measurements that did not correlate were not considered to have an impact on the production of grapes for vinification. In addition, it is important for wineries to produce grapes with high sugar content to produce desirable grapes, and for this purpose, soil pH and hydraulic conductivity should be closely monitored and used as a guide when making improvements through soil amendments.

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