

Article

Fertilization Regulates Grape Yield and Quality in by Altering Soil Nutrients and the Microbial Community

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Abstract: Rational fertilization is a win-win strategy for rural incomes and environmental restoration in ecologically fragile regions. However, the long-term cumulative grape productivity response to soil fertility has rarely been quantified. Here, long-term fertilization experiments (over 15 years) in the desert-oasis transitional zone of Sinkiang, China, were used to evaluate the interactions among grape yield, quality, fertilization, soil nutrients, and microbial communities. There were five treatments, as follows: CK₀ (no planting and no fertilizing); NP (synthetic nitrogen and phosphorus); M (manure only); NPM₁ (0.25 times NP and 0.33 times M); and NPM₂ (NP and 0.5 times M). The grape yield increased with the application of total nitrogen. The soluble solids and reducing sugar contents had significant positive linear correlations with grape yield, but the opposite trend was found between grape yield and titratable acidity and tannin contents. The redundancy analysis showed that fertilization, soil nutrients (soil organic carbon, available nitrogen, and dissolved organic nitrogen), and microbial communities (ratio of fungi to bacteria, ratio of Gram-negative bacteria to Gram-positive bacteria, and total phospholipid fatty acids) accounted for 31.9%, 19.7%, and 26.8% of the grape yield and nutritional ingredients, respectively. The path analysis identified that fertilization, soil nutrients, and the microbial communities were significantly positively associated with the grape yield, soluble solids, and reducing sugars, while their associations with titratable acidity, tannins, and phenols were significantly negative. These results suggested that fertilization is a viable strategy for regulating grape yields and grape quality because it alters soil fertility in ecologically fragile regions.

Keywords: fragile ecology; fertilization; grape yield; grape quality; soil nutrients; soil microorganism



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1. Introduction

The demand for fruit production is continuously increasing with improvements to human living standards. Globally, fruit production increased from 0.48 billion tons in 2000 to 0.72 billion tons in 2017, with an annual increase rate of 2.56% [1]. Grapes, as the second most produced fruit, are becoming increasingly popular due to their nutritional and medicinal values [2,3]. Another major use of grapes is in making wine, especially in Europe, Australia, and America. Wine is considered to be a healthy and hygienic drink [3], and the nutritional ingredients of grapes, including reducing sugars, titratable acidity, and tannin contents, determine the composition and quality of the wine [4]. Obtaining high yields and superior nutritional ingredients requires large temperature differences, the avoidance of rain and dew, and a fine sandy loam soil, but regions with these characteristics are considered to be ecologically fragile [4,5]. Furthermore, these regions are not suitable for grape growth without human interventions. Therefore, it is important to understand how to achieve high grape yields and good nutritional ingredients in ecologically fragile regions.

Rational fertilization is a win-win strategy that achieves high crop productivity and improves the soil quality in ecologically fragile regions [6]. Fertilization with respect to

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