Fertilizer Use Efficiency And Influence Of Rootstocks On Nutrient Uptake And Accumulation In Wine Grapes Grown In The Coastal Valleys Of California

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Introduction

Nitrogen is the fertilizer used most often in California vineyards. Most of the studies conducted on grapevines to determine vine nutritional requirements and the determination of vine nutrient status were conducted in vineyards located in the San Joaquin Valley. In addition, these studies were conducted on vines growing on their own roots. Little nutritional research has been conducted on vines growing in the coastal regions and those that have been conducted were with vines growing on rootstocks that are not currently in high demand (i.e. in replant situations).

Vine nutritional status of grapevines is usually measured by analyzing nutrients in petioles opposite the cluster at a particular pehnological stage (generally bloom or veraison). This technique is also used to determine the efficiency of a fertilizer application in fertilizer experiments. Unfortunately, petiole analysis only gives an instantaneous measure of the vine nutrient status at the time the samples are taken and does not provide quantitative measures of the efficiency of application of the particular nutrient being studied. Other methods have also been used, such as the analysis of the amino acid arginine in the fruit. The use of this technique may be a more appropriate method to determine vine nutritional status. The only way to definitely determine N fertilization used efficiency in a field situation is to use ^{15}N labeled fertilizer. ^{15}N labeled N is a non-radioactive isotope of nitrogen. The amount of ^{15}N present in plant tissues can be quantified with the use of a mass spectrometer.

Objectives

1. Quantify total uptake of nitrogen and potassium in Chardonnay and Cabernet Sauvignon scions grafted onto various rootstocks at different locations.

2. Use isotopically labeled nitrogen (^{15}N) to determine fertilizer use efficiency of premium wine grapes on different rootstocks in the coastal valleys of California.

3. Compare the efficiency of N fertilizer uptake and total N and K uptake by various scion/rootstock combinations with other means to determine vine

nutritional status (for example, petiole analysis at bloom and cluster N and K analysis at harvest).

4. Develop fertilization recommendations for premium wine grapes grown in the coastal regions of California.

Summary

This study will use ^{15}N labeled ammonium nitrate to determine fertilizer use efficiency of two wine grape cultivars (Chardonnay and Cabernet Sauvignon) grown in coastal valleys on different rootstocks. Two different locations will be used per cultivar and at each location similar rootstocks will be used. The rootstocks for the Chardonnay cultivar are 110R, 5C and Freedom. The rootstocks for Cabernet Sauvignon are 110R, 5C and 3309 at one location and 110R, 5C, 1103P, 140 Ru and Freedom at the other location.

The study was initiated in May, 1997, for the Chardonnay vineyards and in June, 1997, for the Cabernet vineyards (shortly after berry set for each cultivar). The fertilizer was applied beneath the emitters while the vineyard was being irrigated. The vines were irrigated at full evapotranspiration (ET). ET was determined by multiplying potential evapotranspiration (Et_o) by a crop coefficient (k_c). The k_c was developed on Chardonnay vines grown in the Carneros district of Napa Valley. To determine the amount of N to apply at berry set vineyard yield was estimated from previous years' harvests and total N required for fruit growth was determined. The amount of ammonium nitrate required to replace the estimated amount of N removed in the crop at harvest in 1997 was applied to six individual vine replicates of each rootstock. This amounted to anywhere from 30 to 45 kg per ha (27 to 40 lbs per acre). The actual amount of N removed in the fruit at harvest in 1997 averaged across rootstocks at the four sites was 33, 31, 22, and 21 kg per ha (29.4, 27.6, 19.6 and 18.7 lbs per acre). The difference in N applied to actual N at harvest was an overestimation of final yield and the amount of N removed from the vineyard in one ton of fruit. It was assumed that one metric tonne of fruit contained 1.5 kg N (3 lbs/ton) while the actual amount of N per unit weight of fruit ranged from 1.58 to 0.98 kg N per tonne (3.15 to 1.96 lbs/ton) of fruit.

Prior to applying the fertilizer, petioles were sampled to determine vineyard nutrient status using the traditional method with total N in the fruit at harvest, the leaves as they fell from the vine and the pruning wood. This included an analysis of petiole nitrate N and total K. Other elements measured on the petioles were: phosphorus, zinc, sodium, chloride, boron, calcium and magnesium. There were large differences in petiole nitrate nitrogen among vineyard locations and among rootstocks at a single location. For example, petiole nitrate nitrogen averaged across rootstocks was 59, 664, 815 and 7070 ppm (on a dry weight basis) at the Oakville, Monterey, Carneros and Paso Robles sites, respectively. At the Paso Robles site, petiole nitrate nitrogen averaged 4042, 6090, 7462, 7878 and 9876 ppm for the 110R, 5C, 140 Ru, 1103P and Freedom rootstocks, respectively.

The percentage of total N in the clusters at harvest, averaged across rootstocks, was 0.426, 0.522, 0.531 and 0.639 (on a dry weight basis) at the Oakville, Monterey, Carneros and Paso Robles sites, respectively. At the Paso Robles site, percent cluster N averaged 0.565, 0.6, 0.669, 0.684 and 0.677 for the 110R, 5C, 140 Ru, 1103P and Freedom rootstocks, respectively. The results would indicate that there does appear to be a relationship between bloom-time petiole analysis and total N found in the fruit at harvest (and also leaf N at leaf fall and cane N at pruning; data not given). However, there is a certain petiole nitrate level in which a further increase do not result in a further increase in tissue total N levels. This petiole nitrate value probably lies in the range from 1000 to 1500 ppm. It is unknown at this time whether a reduction below the above range would negatively impact vine productivity. Further study is required and it is anticipated that data collected in this project for the current growing season (1998) and next year (1999) will refine the specific petiole value.

The total amount of N in the vines (i.e. the N found in the vine's clusters, leaves after leaf fall and canes at pruning) averaged 58.7, 47.2, 43.7 and 44.7 kg per ha (52.3, 42.0, 38.9 and 39.8 lbs N per acre) at the Carneros, Monterey, Paso Robles and Oakville sites, respectively. It is apparent that these values were not related to the petiole nitrate levels recorded at those sites. Many assume that a high value of nitrate in the petiole is associated with a greater uptake of nitrogen. In addition, petiole nitrate levels of individual rootstocks were not associated with total N accumulated by an individual rootstock. For example, at all locations scions on the 5C rootstock had greater petiole nitrate levels than those on 110R. However, Chardonnay scions on 110R accumulated more N in the clusters, leaves and canes than those on 5C, while Cabernet scions on 110R accumulated less nitrogen than those on 5C.

Fertilizer use efficiency (FUE) (ratio of applied ^{15}N to ^{15}N taken up by the vine) was calculated for all rootstock/scion/location combinations. There were little differences among rootstocks at a given location. This was anticipated as all rootstocks were culturally treated the same (i.e. vertical trellis system, shoot positioned, hedged at a certain height and drip irrigated according to best estimates of vine water requirements). All fertilizer applications were such that the nitrogen was applied directly beneath an emitter while irrigating. There were somewhat larger differences in fertilizer use efficiency among locations. Fertilizer use efficiency, when averaged across rootstocks, was 10.3, 3.81, 3.45 and 11.5% at the Carneros, Monterey, Paso Robles and Oakville sites, respectively. There are several explanations for the differences among sites. The extremely high petiole nitrate levels at the Paso Robles vineyard may indicate an abundance of soil nitrogen at that site thus diluting the uptake of fertilizer N. At the Monterey site, the cooperator applied a NPK fertilizer without my prior knowledge again diluting the ^{15}N fertilizer I applied at berry set. The higher FUE at the Carneros and Oakville sites may have been due to the fact that neither vineyard had been fertilized since planting and the Oakville vineyard had very low petiole nitrate levels when sampled at bloom (an average of 59 ppm).

The above FUEs seem quite low compared to a FUE of approximately 40% the PI found on Thompson Seedless grapevines grown in the San Joaquin Valley. It should be pointed out that the FUEs presented in this summary were based upon N found in the fruit, leaves and prunings while those on Thompson Seedless also analyzed the root system, trunk and fruiting wood. Those three organs contained approximately 40% of the total ^{15}N labeled fertilizer taken up by the vines in that study. It is anticipated that the labeled fertilizer in the trunk, cordons and root systems of the vines used in this study will be remobilized and found in the clusters, leaves and pruning when those organs are harvested at the end of the 1998 and 1999 growing seasons. That is why it was important that this study be conducted for at least three growing seasons. In addition, currently I have permission to harvest the entire vine at two of the locations so I will be able to determine if any residual ^{15}N remains in the trunk, cordon or root system after three years.