

Abstract

Table grape production requires adequate nitrogen (N) to support vine performance and optimize yield. However, excess N fertilization contributes to groundwater contamination and air pollution, stressing the need for precision N management strategies. This study aimed to quantitatively define table grape N requirements, identify the primary drivers of N uptake, and quantify the relationship between N fertigation and vine growth, yield, and fruit quality. Forty 'Early Sweet' (early-maturing, white) and 'Crimson Seedless' (late-maturing, red) vines were grown in 500 L drainage lysimeters over two seasons and subjected to five N fertigation levels (10–200 ppm). Irrigation and drainage volumes and N concentrations were monitored biweekly. Vegetative growth, leaf composition, and ripening progression were measured at key stages, and fruit quality was analyzed at ripeness.

Seasonal N uptake pattern was independent of reproductive phenology and primarily driven by water uptake and N availability. Irrigation N concentrations of ~40 ppm consistently matched vine uptake and supported optimal growth and yield. Lower N levels advanced sugar accumulation, reduced fruit pH, enhanced anthocyanin content, and improved N use efficiency, particularly in 'Crimson Seedless'. Petiole N concentration at bloom emerged as the most reliable indicator of vine N nutrition and a strong predictor of fruit N and anthocyanin levels at ripeness. N fertilization rates significantly influenced the petiole mineral profile, specifically, the levels of Ca, Mg, S, Mn, and Zn. Taken together, our findings provide a physiological and diagnostic framework for refining N fertigation practices in table grape production to improve fruit quality and sustainability.