Nitrogen Requirements, Use-efficiency

By Larry E. Williams

Abstract

The nitrogen requirements of Thompson seedless grapevines and the utilization of N for vine growth from the soil, fertilizers and vine reserves were quantified.

When vines were fertilized with 25 pounds of nitrogen per acre shortly after bloom, the fertilizer use efficiency (percentage of fertilizer N taken up by the vine divided by total fertilizer N applied) was approximately 42 percent and 14 percent for drip and furrow irrigated vines, respectively. Vines that were fertilized with 2.76 pounds of nitrogen per acre every two weeks over a 20-week period had taken up 34 percent of the applied N at the end of the growing season. The proportion of fertilizer N found in any organ of the vine in the three treatments was never greater than 12 percent of the total N in that organ.

The results indicate that 60 percent of the nitrogen required for new vegetative and reproductive growth of Thompson seedless vines in the San Joaquin Valley comes from soil nitrogen, even when the vines are fertilized.

Objectives

Nitrogen is the most widely used fertilizer in San Joaquin Valley vineyards. There are several unknowns which need to be considered when determining vineyard fertilization needs. Leaves which fall from the vine and prunings incorporated back into the soil may contain as much as 35 pounds of nitrogen per acre. It is unknown how rapidly this N source is broken and how much of it, if any, will be utilized by the vine the following season.

The N fertilizer use efficiency (FUE) depends upon the amount of N that may be leached from the soil or denitrified and this is influenced by soil type, rainfall and irrigation amounts. The timing of N fertilizer application and irrigation method also will determine the efficiency of the fertilization program.

Lastly, reserves from the permanent structures of the vine may be translocated and used for new shoot and cluster growth throughout the growing season. It is unknown how much of these reserves are utilized by vines growing in the field.

The research reported here was conducted to determine the seasonal N demands of field-grown Thompson seedless grapevines grown in the San Joaquin Valley. All vine organs were destructively harvested at various intervals throughout two growing seasons and dry matter and N content measured. In addition, isotopically labeled potassium nitrate (10N) fertilizer was used to determine the fertilizer use efficiency of Thompson seedless vines that were either drip or furrow irrigated.

Procedures

Thompson seedless grapevines (*Vitis vinifera* L.) in a 5-year-old vineyard at the Kearney Agricultural Center near Fresno, Calif., were used in this study. The soil at this location is a Hanford sandy-loam. The vines were head trained and cane pruned. The trellis system had an 18-inch crossarm with a wire at either end. The crossarm was approximately 5.5 feet above the soil. Vine and row spacings were 8 and 12 feet, respectively.

In 1989, Thompson seedless vines that were either drip or furrow irrigated were used to determine N fertilizer use efficiency. The vines were trained and the trellis systems in these vineyards were as described above. The drip irrigated vines were irrigated according to best estimates of vineyard evapotranspiration and there were two one-gallon per hour emitters per vine.

The furrow vines were irrigated when 50 percent of the available soil moisture content had been depleted. Neither vineyard had been fertilized since planting. On May 18, 1989, (berry size approximately 8 mm in diameter) five vines in each vineyard were fertilized with the equivalent of 25 pounds per acre using potassium nitrate or ammonium sulfate containing 5.0 atom excess 15N.

Nitrogen fertilizers containing the non-radioactive N isotope (15N) are used to distinguish between N obtained from the soil by the vine and that obtained from the fertilizer.

An additional set of five drip-irrigated vines were fertilized 10 times during the 1989 growing season beginning April 20 and ending Aug. 17 (at approximately two-week intervals). Vines were given 2.76 grams of nitrogen per vine on each date of the 15N labeled potassium nitrate for a seasonal application of 27.6 grams of nitrogen per vine (27.6 pounds per acre).

A solution of the nitrogen fertilizer was poured beneath each emitter for the drip irrigated vines. A furrow 6 inches in depth and 1.5 feet from the vine was made along either side of the furrow irrigated vines and the fertilizer solution poured along the entire length. The furrow was then covered with soil and the vines irrigated on the same day.

At fruit harvest, clusters of all experimental vines were weighed, subsampled and dried. As the leaves on the experimental vines fell during the fall season, they were collected, dried and weighed. Just prior to budbreak in 1990, the canes, trunk and roots from each vine were harvested, dried, weighed and subsampled. Finely ground tissue of all organs was analyzed for total N and 15N by Isotope Services Inc., Los Alamos, N.M.

Results

The grape yields of the fertilizer use efficiency experimental vines in the drip and furrow irrigated vineyards averaged 63 and 47 pounds per vine, respectively. The difference in yield between the two irrigation methods was due to the fact that space limitations prevented the use of more vigorous vines elsewhere in the furrow irrigated portion of the vineyard.

The total amount of fertilizer N taken up by the vines across all treatments ranged from 10 percent to 42 percent of the applied N fertilizer (Table 1). The greatest percentage of N fertilizer taken up by the vine was found in the clusters for all treatments (data not given). It was 40 percent when averaged across all treatments.

The percentage of fertilizer N taken up by drip irrigated vines found in the root system was double that found in the roots of the furrow irrigated vines. The percentage of fertilizer N found in the clusters, leaves and stems of the drip irrigated treatments averaged 10 percent of their annual N requirement (data not given).

The N fertilizer supplied 6 percent of the annual requirement of the clusters, leaves and stems of the furrow irrigated vines.

Another set of vines that had been continuously fertilized in 1989 were not harvested until the end of the growing season in 1990. The fertilizer N in the roots and trunk of the vines in 1989 represent the reserves in those structures containing 15N labeled fertilizer (Table 2).

The decrease in the amount of 15N nitrogen per vine in the roots and trunk from 1989 to 1990 represents the amount of fertilizer N remobilized during the 1990 growing season from those two organs. The decrease in N content from the roots and trunk between the two seasons 0.71 grams per vine is less than the total found in the clusters, leaves and stems in 1990 (3.96 grams per vine.) This indicates that there was residual labeled fertilizer N in the soil from the 1989 growing season taken up by those vines in 1990.

Discussion

A timing of N fertilizer application study conducted in the San Joaquin Valley previously had indicated that a July and post-harvest application in September resulted in the highest concentration of fertilizer N in the storage organs of the vine. This was compared to an April application. Based on this information, it was decided to apply the fertilizer in this study subsequent to berry set in order to maximize the amount of N required by the clusters that was derived from fertilizer N. Much of the shoot growth of the vines had taken place by this time.

The fertilizer use efficiency of the drip irrigated vines was dramatically greater than that of the furrow irrigated vines (Table 1). However, the efficiency of a continuous application of N fertil-

Table 1. Effect of irrigation type and form of nitrogen on total fertilizer N uptake and fertilizer use efficiency (FUE).

Treatment	Total Fertilizer N in Vine[1]	FUE[2]
Drip (NO_3)	10.0	42%
Drip (NH_4)	9.3	37%
Furrow (NO_3)	3.4	14%
Furrow (NH_4)	2.6	10%
Drip (Cont)	9.5	38%

[1]g Fertilizer N per vine (g N per vine is equivalent to lbs. N per acre).
[2] FUE = Total Fert. ^{15}N in Vine/Total Fert. ^{15}N applied.

Table 2. The distribution of fertilizer ^{15}N in individual vine organs of vines fertilized in 1989 and harvested in either 1989 or 1990.

Treatment[1]	Year Harvested	Vine Organs: Clusters	Leaves	Stems[2]	Trunk	Roots	Total
		(g N vine)					
Drip (Cont)	1989	3.23	1.81	0.86	1.14	2.47	9.51
Drip (Cont)	1990	1.78	1.40	0.78	0.58	2.32	6.86

[1]Vines fertilized with ^{15}N every two weeks during 1989 growing season for a total of 27.5 g N per vine (this is equivalent to 27.6 lbs. N per acre).
[2]Stems include main axis of shoot and fruiting canes.

izer under drip irrigation in this vineyard was no greater than that of a single application after berry set. There was residual fertilizer N in the soil available for use the following season for the treatment (Table 2). The use of this N increased the FUE of that treatment to approximately 54 percent over the two-year period.

Under drip irrigation, greater than 60 percent of the applied fertilizer N was found in the clusters and root system. This occurred regardless of whether vines were fertilized once or continuously throughout the season. A smaller percentage of fertilizer N was found in the roots of furrow irrigated vines compared to the drip irrigated vines.

The differences between the two irrigation treatments are probably due to the differences in the distribution pattern of roots as a function of irrigation method. The high concentration of roots under each emitter for drip irrigated vines would place them where most of the fertilizer N was applied. Since the root systems of furrow irrigated vines are dispersed more evenly throughout the soil profile, the placement of the fertilizer for this treatment would limit the uptake of fertilizer N to the narrow zone of roots closest to where the N was applied to the soil. The fertilizer use efficiency and the proportion of N found in the roots of the furrow irrigated treatment was the lowest of all three treatments, however, the proportion of fertilizer N found in the clusters in that treatment was the greatest.

Conclusion

Results presented here indicate that the nitrogen reserves in the trunk and root system play an important role in supplying the new vegetative and reproductive growth of the vine with N. From 30-40 percent of the N found in new growth may be derived from reserves. Before and after fruit harvest, the N reserves of the trunk and root system are replenished.

The fertilizer use efficiency of drip irrigated vines was three times more efficient than that of furrow irrigated vines. However, the application of N fertilizer to drip irrigated vines still only supplied 10 percent of the annual N required by the vines under the conditions of this experiment.

There was only a small difference in efficiency between the two forms of N fertilizer (nitrate vs. ammonia). The data obtained from this study would indicate that the majority of the N required for seasonal growth of all organs of vines at this location must come from soil N or N in the irrigation water, even when the vines are fertilized. □

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