Nitrogen utilization by green beans

Willamette Valley green bean growers routinely use 50 to 150 lb nitrogen /a to produce their crop. The application of nitrogen is made with the expectation that an agronomic trait such as yield will be increased. The increase in yield is expected to produce an increase in income and profit. In addition to changing an agronomic trait and being economically advantageous, any nutrient application should also be environmentally sound.

Nitrate-N (NO$_3$-N) is the primary form of N available to crops and also moves quite readily with water through the soil. Any crop that is adequately supplied with N and irrigated judiciously will leave some NO$_3$-N in the soil at harvest. Oregon State University extension guidelines state that a low amount of NO$_3$-N in the surface foot of soil at harvest is less than 35 lb/a (Marx et al., 1998). Nitrate-N remaining in the soil at harvest is both an economic and environmental concern. The economic concern is unused investment that will be lost through leaching with winter rainfall. The loss to groundwater or to surface waters is the environmental concern.

We surveyed grower fields in 1993, 1994, and 1995 for NO$_3$-N remaining in the soil after harvest of several processing vegetable crops. Figure 1 provides data from 1995 and raises the concern that N is being applied beyond crop use for green beans. An average of 8 green bean fields contained approximately 75 lb NO$_3$-N/a in the top foot of soil. The amount of N remaining in green bean fields at harvest is equal to the N found in the above ground portion of some green bean fields at harvest, and twice the amount considered to be “low” by OSU extension guidelines.
Figure 1. Total NO$_3$-N from the surface foot of soil at harvest for processing vegetable fields from the Willamette Valley in 1995.

Another perspective of NO$_3$-N in the soil at harvest for green bean production is shown in Figure 2. Two data sets have N rate applied plotted against NO$_3$-N remaining in the surface foot of soil at harvest. The longer bottom line with points as circles is data from N rate trials at the North Willamette Research and Extension Center in 1994 and 1995. The shorter line with points as squares is data from our survey of grower fields in 1993, 1994, and 1995. Both show the relationship of increasing N in the soil at harvest with increasing N rate. Note that even when no N was applied to the crop, some NO$_3$-N was measured in the field at harvest. The data from grower fields shows that about two-thirds of the applied N can be found in the surface foot of soil as NO$_3$-N at harvest.

Figure 2. Nitrate-N remaining in the surface foot of soil of green bean fields at harvest from N rate plots, lower line, and grower fields, upper line.

The amount of N remaining is a lost or missed economic opportunity. If less N is used and the yield remains the same, production cost will decrease and profit will increase. Growers typically want to use enough N so that it is not limiting to yield. The question with which we wrestle is “how much N is enough?”.

Let’s explore the question of “how much N is enough?” or N rate. Figure 3 is green bean pod yield in response to N application rate at the North Willamette Research and Extension Center for 1994 and 1995. Statistically and logically, the zero N rate can be rejected as too low. It obviously limited yield. Similarly, the 160 lb N/a rate can be rejected as being too high. No yield increase was achieved with this rate. The same statement can be made for the 120 lb N/a rate. Only two rates remain, 40 and 80 lb N/a. In 1994 40 lb N/a produced the optimum yield and in 1995, the 80 lb rate produced the optimum yield.
Figure 3. Green bean yield and N rate from the North Willamette Research and Extension Center in 1994 and 1995.

The Oregon State University Extension Service Fertilizer Guide for Bush Beans recommends (Mansour et al. 1983) "rates of 50 to 80 lb N/a where beans are grown on fields having a history of heavy fertilizer rates. Nitrogen rates of 80 to 110 lb/a are recommended where forage legumes or heavily fertilized vegetable crops were not grown the previous year. The previous crop for the rate study at the North Willamette Research and Extension Center was fallow, which would be equivalent to a bean crop that did not follow heavy fertilizer application or a forage legume.

Nitrogen was applied to Bush Blue Lake-47 green beans at 0, 35, 70, and 105 lb/a at a research facility in Geneva, New York in 1981 (Peck and MacDonald, 1984). A regression analysis of yield data from an August 10 harvest showed that an N rate of 50 lb/a produced optimum yield of 8.8 t/a. Harvesting 3 days later increased the pod yield to 9.9 t/a and optimum N rate to 100 lb/a. The N rates for optimum yield are within the ranges given in the OSU fertilizer guide and found with recent research. In addition, these results show continued rapid pod development and N use at harvest.

The N recommendation from the extension fertilizer guide is general. Nitrogen recommendations need to be site specific. The relatively large amount of NO$_3$-N remaining in the soil at harvest is probably a result of inadequate estimation of the amount of N that will be available to the crop. What can be done to reduce amount of NO$_3$-N in the soil at harvest?

The first step toward reduction of unused N is to know the pattern of N uptake for green beans. If the pattern of uptake or demand is known, we can apply N at an appropriate time. Nitrogen applied after peak or complete N uptake remains in the soil at harvest.
The pattern of green bean N uptake is shown in Figure 4. This data was collected in 2000 from beans planted on May 26 and harvested in early August. Nitrogen uptake is quite small for the first two or three weeks of growth. At standard seeding rates, bean seed contains 2 to 3 lb N/a. During this period, approximately the same amount of N is found in bean plants as is contained in the seed. After very slow N uptake, the crop begins to accumulate N rapidly. Even so, at more than six weeks after planting, less than 20% of the N in the crop at harvest has been accumulated.

![Figure 4. Cumulative N uptake for green beans in 2000.](image)

About six weeks after planting, the N uptake changes dramatically and increases rapidly until harvest. The maximum rate per day of N uptake, 4 lb N/a/day, is reached in mid-July, about 7 weeks after planting, Figure 5. Nitrogen applied after mid-July will probably not be used efficiently by the bean crop.

![Figure 5. N accumulation rate, lb/a/day, by green beans in 2000.](image)
To be agronomically, economically and environmentally sound, nutrient applications have to address four parameters, rate of nutrient, timing of application, source of nutrient, and method of application. The Oregon research from 1994 and 1995, fertilizer guide, and literature from New York provide a brief examination of N rate for green bean production. The work in 2000 provides the necessary data for time of N application. The source of material and method of application are choices for the producer.

Determination of the N that will be available at each site is needed before fertilizer N efficiency can be increased.

Literature Cited


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