Improving nitrogen use in strawberry production

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Strawberry growers are well aware of the increasing regulatory pressure on agriculture to reduce nitrate-nitrogen (NO_3-N) leaching to groundwater. For the first time, the Regional Water Quality Control Board has proposed a numerical target for seasonal N fertilization for strawberry production; that target is 120% of total crop N uptake. Over the 2009-10 and 2010-11 production seasons we conducted extensive monitoring in several dozen strawberry fields in the Watsonville-Salinas area to develop an understanding of the nitrogen dynamics of current production practices, and to identify ways in which nitrogen use efficiency might be improved.

All fields were planted either with 'Albion' or a common proprietary day-neutral variety. Root zone (top 12 inch) soil sampling for NO_3-N concentration was done on a monthly basis from April through September; in 8 fields we also conducted soil NO_3-N sampling at the time of planting in the fall. Cooperating growers provided detailed records of their fertilizer management. In seven fields crop N uptake was documented by collecting 8-12 whole plants per field on a monthly basis from March to September. Fruits were removed, and the vegetative portion (leaves and crowns) were oven-dried, ground and analyzed for N content. At each sampling date ripe fruit were also analyzed, and the amount of N contained in fruit was estimated by multiplying the fruit N concentration by the marketable yield during each sampling period.

In three fields we also evaluated the efficiency of current preplant controlled release fertilizer (CRF) use. Sites 1 and 2 were fields near Salinas and Watsonville, respectively, and were planted with 'Albion'; soil texture at both sites was a loam. Site 3 was a field of clay loam soil near Castroville, and was planted with a proprietary day-neutral cultivar. At sites 1 and 2 the growers' standard CRF application (18-8-13, 7-9 month release rating, 108 lb N/acre) was compared to a half rate application; at site 3 both a half rate and no CRF were compared to the grower's standard application (18-8-13, 7-9 month release rating, 77 lb N/acre). Each trial utilized a randomized block experimental design, with 4 replicate plots per CRF rate. At all sites marketable yield data were collected by experienced commercial harvest personnel from April to October. To document the pattern of N release from the CRF, polyester mesh bags containing 4 g of the 18-8-13 CRF were buried in soil beds on November 4 at site 1 and November 23 at site 2. On approximately monthly intervals, 3 replicate bags of each CRF were recovered, and the amount of N remaining in the CRF granules was determined.

Results

Crop N uptake showed a characteristic pattern in all fields (Fig. 1). From crown planting through March, crop N uptake was slow, averaging less than 25 lb N/acre by the first of April. From that point forward crop N increased at a steady rate of approximately 1 lb/acre/day through August; vigorous fields were slightly above that rate, with less vigorous fields somewhat below. By the end of August seasonal N uptake in these fields averaged about 170 lb/acre. This estimate was based only on above-ground vegetation and marketable fruit; adding the N content of roots and cull fruit would add approximately 30 lb/acre, meaning that total crop N uptake would average about 200 lb N/acre/season. Crops that continued to be harvested through the fall would obviously continue to take up N, although at a slower rate as the weather cooled and growth rate declined.

Complete fertilizer records were obtained for 15 of the monitored fields. Growers had widely varying fertilization programs, ranging from a seasonal total of 126-433 lb N/acre (Fig. 2). All but one grower applied preplant CRF, with an average application rate of about 90 lb N/acre. Neither preplant CRF rate, nor total seasonal N application rate, was correlated with the marketable yield obtained.

There was a trend toward declining root zone soil NO_3-N as the season progressed (Fig. 3). Averaged across fields, soil NO_3-N at planting was typically high; most strawberry plantings in this region follow vegetable crops, and therefore often begin the strawberry season with high residual soil NO_3-N. By June the average soil NO_3-N had fallen below 10 PPM, where it remained for the rest of the season. There were individual fields in which summer soil NO_3-N was maintained above 20 PPM by high levels of fertigation, but as a group they were no more productive than fields with lower soil NO_3-N levels.

The pattern of N release from the 18-8-13 CRF, averaged over the two field sites, is shown in Fig. 4. Approximately 75% of the initial N content had been released by the end of March. This rate of N release was much faster than the rate of strawberry N uptake over the winter; a 90 lb N/acre preplant application would release more than 60 lb N by the end of March, while plant sampling showed that crop N uptake by that time was typically less than 25 lb/acre.

The results of the CRF rate comparison trials reinforced the conclusion that current CRF use patterns are not efficient. At the end of April crop N uptake averaged only 31 lb N/acre across sites, with CRF rate having minimal effect on crop N uptake (Fig. 5). Reducing preplant CRF (site 1) or eliminating it altogether (site 3) did not affect marketable fruit yield (Fig. 6). However, reducing the CRF rate at site 2 resulted in a statistically significant 9% yield reduction. Fruit yield improvement with the full CRF rate at site 2 may have been related to greater NO_3-N leaching at that site resulting from high rainfall (22 inches by April 1 vs. 14 and 13 inches at sites 1 and 3, respectively), as well as heavy irrigation applied by the grower in April and May. Rather than routinely using high preplant CRF rates to protect against such unusually high winter rainfall or inefficient irrigation, a program of more accurate irrigation scheduling, soil NO_3-N testing in the spring, and earlier fertigation (where appropriate) would be a more nitrogen-efficient practice.

Conclusions:

Our results contain some good news and some bad news. The good news is that the proposed seasonal N fertilization target of 120% of crop N uptake is currently being met by a number of growers; assuming a seasonal crop uptake of 200 lb N/acre, more than half of the monitored fields for which we obtained fertilization records met the target. The bad news is that some growers are substantially above that target. For those growers, our data suggests two ways to reduce N fertilization rates with minimal risk to crop productivity. First, reconsider current CRF practices. Reducing CRF rates, at least in field situations in which winter N availability is likely to be adequate (medium- to heavy-textured soils being rotated out of vegetable crops), and/or switching to a CRF with a slower N release pattern that more closely matches crop N uptake, will likely reduce the amount of CRF N that is lost from the field. Second, use a fertigation program that supplies N at a rate similar to crop N uptake. Fertigation far in excess of crop N demand (about 1 lb N per acre per day) is likely to lead to NO_3-N leaching, not improved growth.

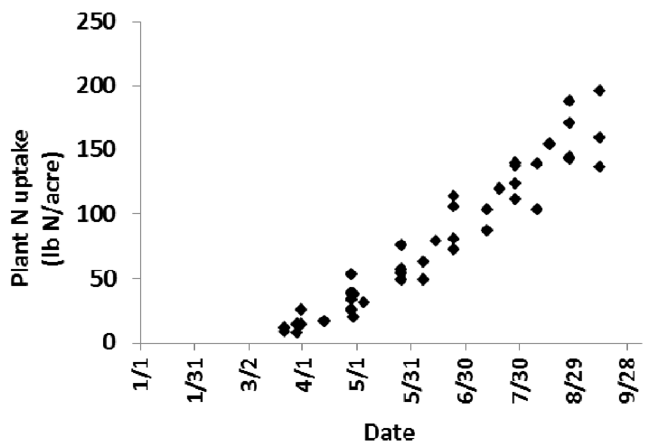

Fig. 1. Pattern of strawberry N uptake over the season; data from 7 commercial fields.

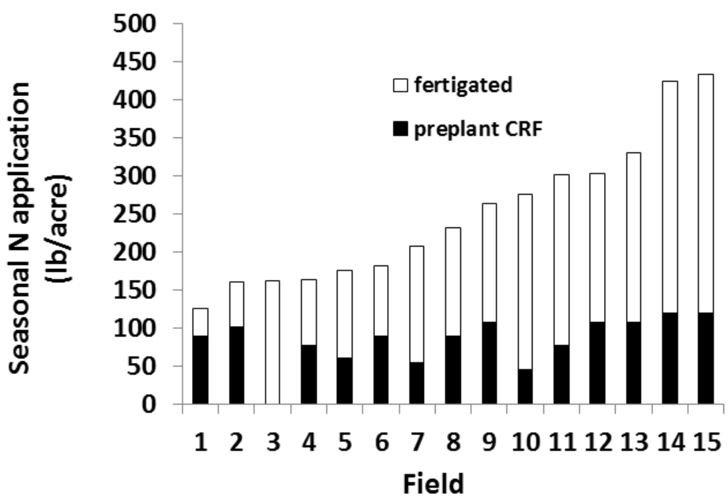

Fig. 2. Seasonal N application in 15 of the monitored fields.

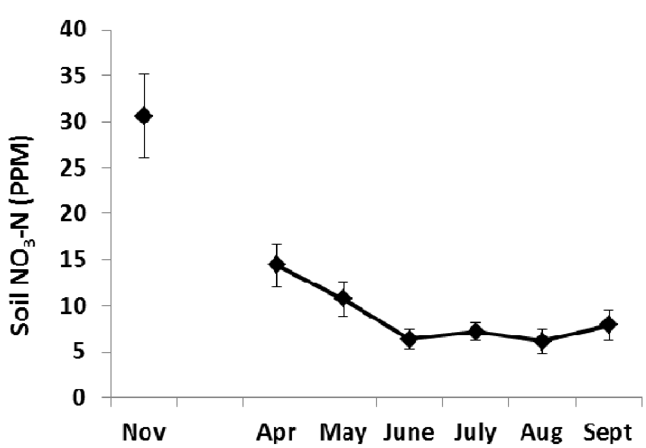

Fig. 3. Pattern of root zone (top 12 inch) soil NO_3-N over the production season.

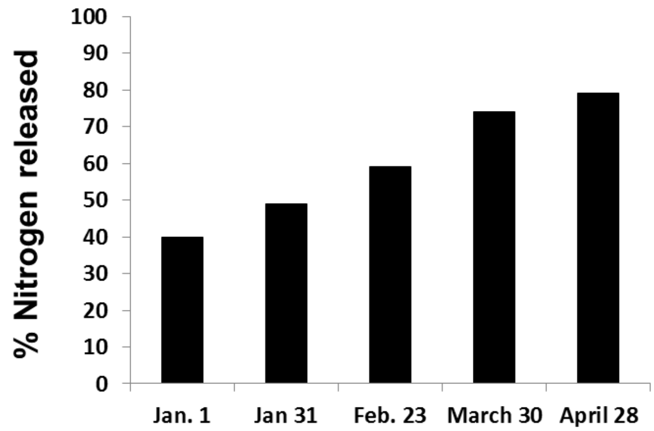

Fig. 4. Pattern of nitrogen release from 18-8-13 controlled release fertilizer (CRF).

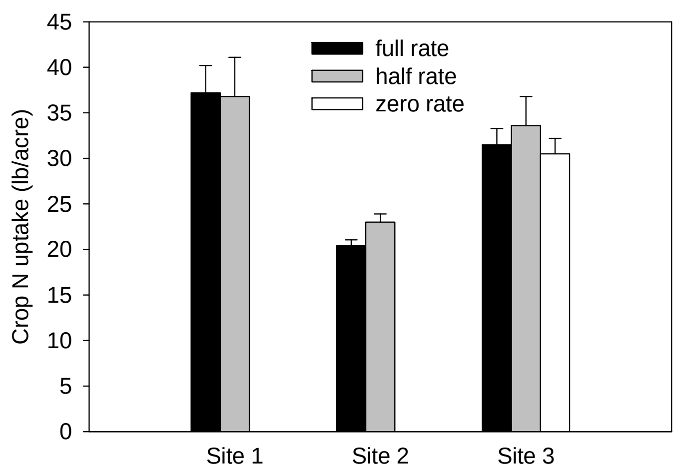

Fig. 5. Effect of preplant controlled release fertilizer rate (CRF) on crop nitrogen uptake by the end of April; bars indicate the standard error of measurement.

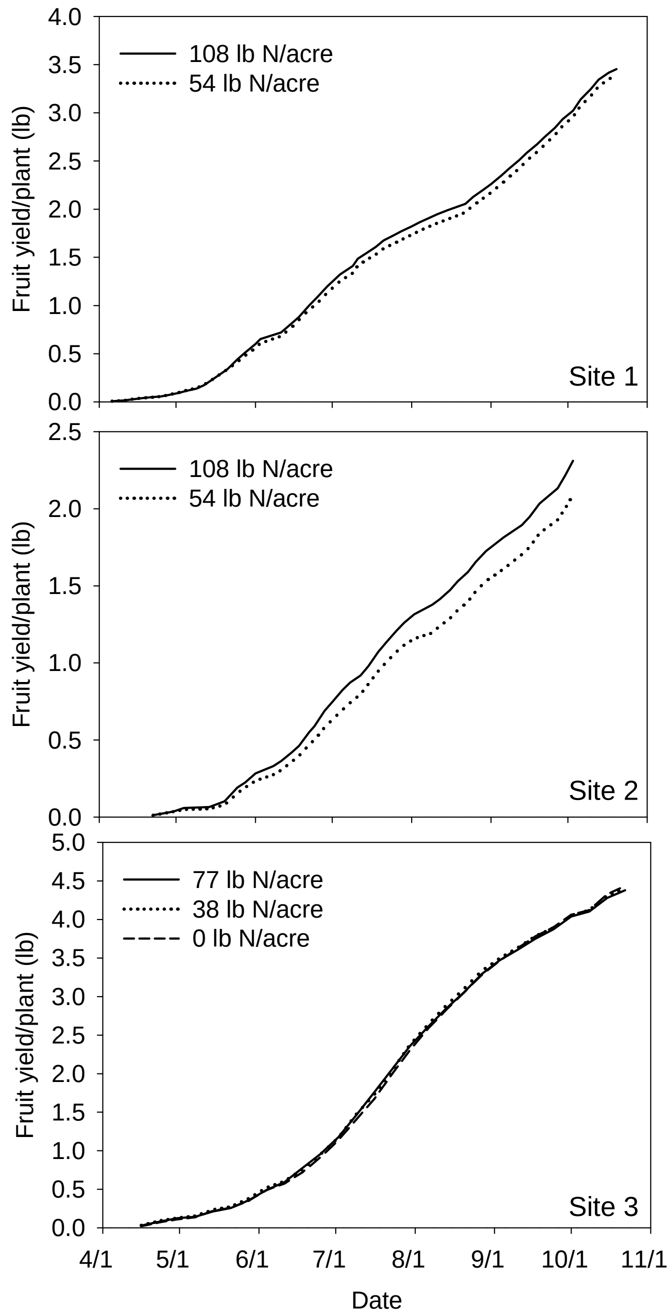

Fig. 6. Effect of preplant controlled release fertilizer (CRF) rate on marketable fruit yield.