Pre-plant slow-release nitrogen fertilizer evaluation in strawberry

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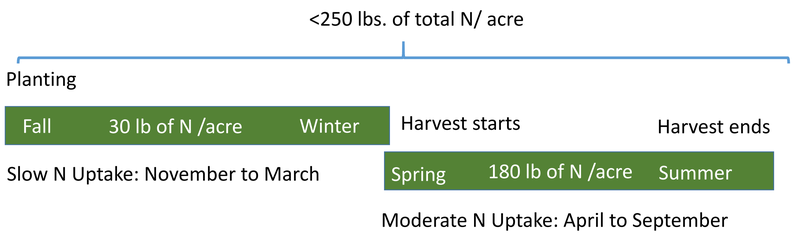
Introduction

Nitrogen management is one of the most challenging aspects of nutrient management in strawberry (Fragaria × ananassa) production, particularly in the California northern district (Watsonville and Salinas). **Excess of nitrogen application results in potential for leaching and possibly in low fruit quality; low nitrogen availability for crop uptake can result in reduced yield.**



Plant nitrogen uptake is slow from planting to the beginning of harvest (about 30 lb/ac from November to March), and moderate and constant from spring until crop termination (1 lb/ac day from April to September). Thus, the generally recommended seasonal crop demand is below 250 lb/acre (Bottoms et al., 2013).

Pre-plant slow-release fertilizers consisting of a formula of nitrogen, phosphorous and potassium coated by a polymer layer are commonly used in strawberry production. However, there are concerns on the rate of release of the fertilizer, and some evidence that much of the fertilizer may be released during winter months, when crop uptake is low and leaching potential due to rains is high (Bolda et al, 2011). Therefore, some growers rely mostly on fertigation during spring and summer rather than on pre-plant applications to increase crop nitrogen availability. We conducted an applied research and extension experiment in collaboration with four commercial strawberry growers with the goal of informing nitrogen management and evaluating different strategies.

Materials and Methods

Different nitrogen management strategies were applied at each ranch, following the grower standard practice (**Table 1**). The pre-plant slow release applied was Agriform, either Universal Mix (8-months release, 18-8-13) or Northern CA Long Term (12-month release, 18-6-12). Three out of four growers supplemented the pre-plant nitrogen application by injecting liquid fertilizers in the irrigation system during production season. We monitored soil nitrate concentrations monthly using soil nitrogen quick tests (MQuant nitrate test strips, **Figure 1**) with the method proposed by Hartz (1994). Soil samples were taken at two depths, at the first and second foot. Total yields were measured by growers as part of commercial practice and in one ranch we measured yields weekly with a strip plot design with three replicates. Yield data were analyzed with ANOVA and repeated measures.

Results

The total amount of nitrogen applied at the four ranches in the study varied substantially, but all ranches obtained good commercial yields (above 60,000 lb of fruit per year, **Table 1**).

Ranches 1, 3 and 4 reported higher yields associated with higher rate of pre-plant fertilizer, while in Ranch 2 no differences were observed. In Ranch 1, yields were measured weekly in a strip plot, the yield was about 13% higher for the pre-plant treatment than in the fertigation treatment (**Figure 2**), despite the pre-plant plot received from fertilizer less nitrogen than the fertigation treatment (117 vs. 158 lb of nitrogen/acre). ANOVA indicated that these differences were statistically significant (**Table 2**). Irrigation management at this ranch was very close to crop evapotranspiration, while over-irrigation occurred in other ranches (data not shown). There was strong evidence of nitrate leaching by winter rains and some evidence of leaching due to over irrigation (**Figure 3**). We also found some evidence that fertilizer beads were still in the soil as late as June, or 8 months after application (**Figure 1**).

Differences in plant vigor were visually observed at the beginning of spring only in Ranch 1 and by June differences were not discernable (**Figure 4**). In all ranches, residual nitrogen from the previous crop and nitrate in the irrigation water provided substantial contributions to the crop total nitrogen balance, contributing to a seasonal nitrogen availability over 300 lb/ac in ranches in the low pre-plant plots of Ranches 1 and 2 (**Table 1**), while in Ranches 3 and 4 the total nitrogen available in the low pre-plant treatment was below recommended seasonal crop demand (158 and 197 lb/ac respectively). In Ranch 2, nitrate in the irrigation water and estimated nitrogen release from soil mineralization were sufficient to match the rate of 1 lb/acre day of crop uptake.

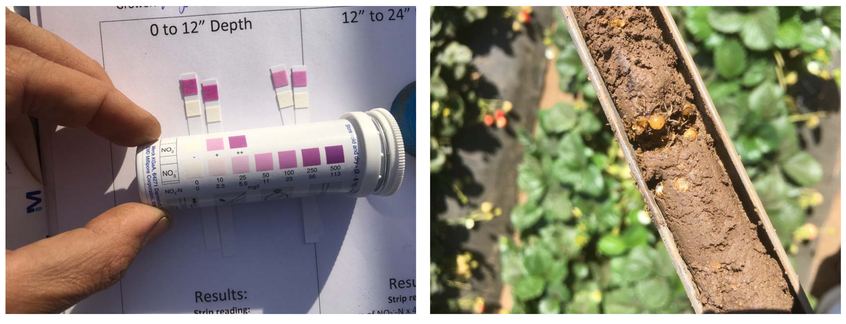


Figure 1. Example of the nitrate quick test results and fertilizer beads found in a soil sample in June.

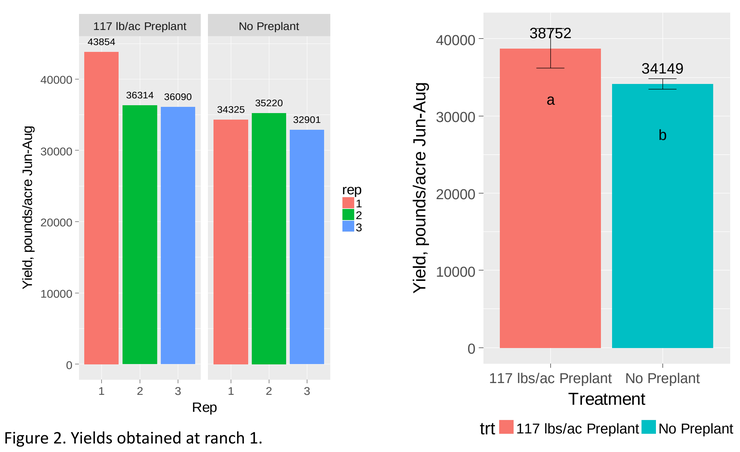


Figure 2. Yields obtained at ranch 1.

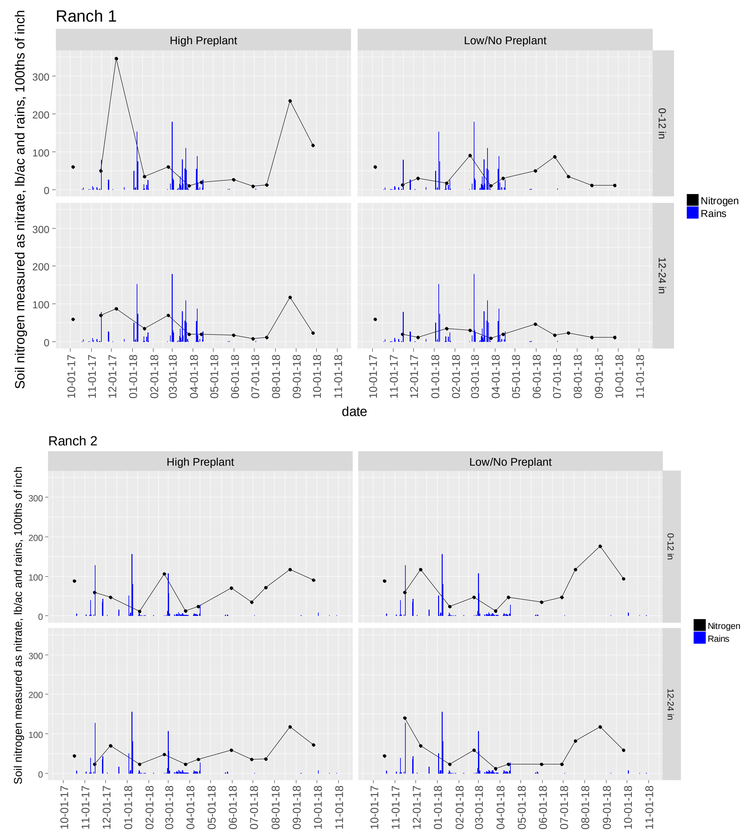


Figure 3. Soil nitrate sampling and rains from the weather station.

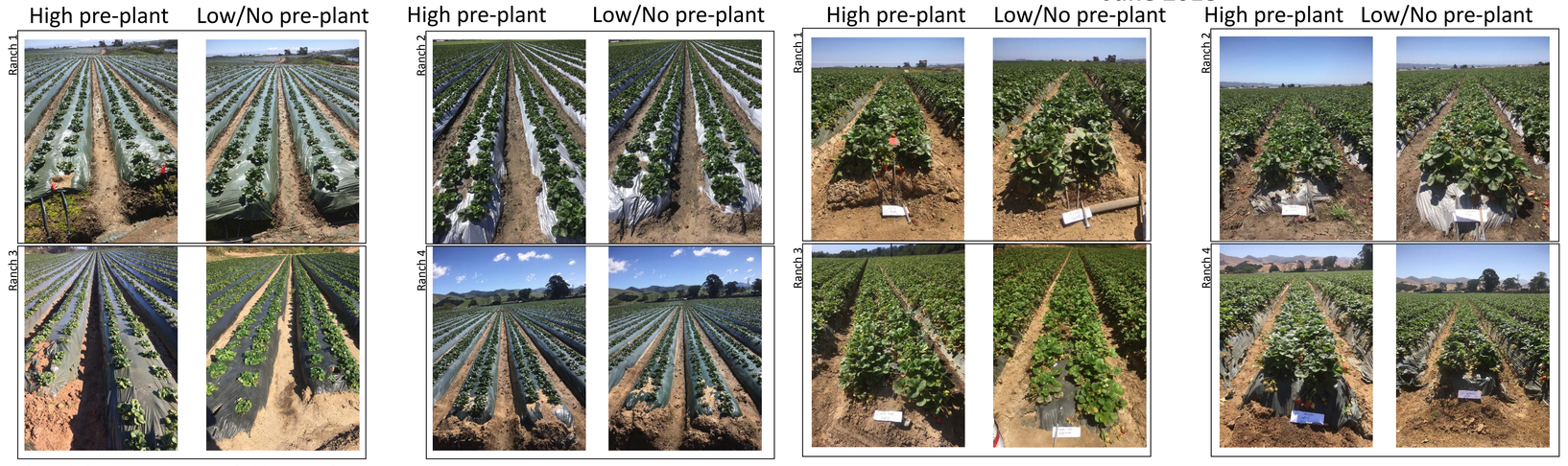


Figure 4. Canopy development in March and in June.

Discussion

The application of pre-plant fertilizer in strawberry production used to be very common in the northern district, but some growers have been adopting nitrogen management based on fertigation. The drivers of this transition are lower costs of fertilizer and anecdotal reports that high soil nitrogen concentrations negatively affect fruit quality. Previous work from the UC cooperative extension suggest that most slow release fertilizer is released in the first six months of the crop when uptake is low and leaching potential by rain is high (Bolda, et al., 2011). However, in this study we found some evidence that fertilizer was still available as late as 8 months after application, and statistically significant increase in yield in one ranch in the pre-plant treatment. However, this data came from a one-bed strip (52 inch wide, about 300 ft long) in the ranch and may not be representative of field conditions. Additionally, most of the difference in yield came from one rep, while the other reps in the pre-plant plot had yield comparable to the fertigation plot (**Figure 2**). In the other two ranches that showed lower yield in the low pre-plant treatment, the total quantities of nitrogen applied were below recommended crop uptake.

We also found strong evidence of nitrate leaching following rain events, suggesting that applying large quantities of pre-plant nitrogen in fall may lead to low nitrogen use efficiency. The nitrogen balance at the ranches showed that in some cases the contribution from non-fertilizer sources can provide a substantial quantity of nitrogen, that sometimes can even match the crop uptake. This was the case in Ranch 2 where no differences in yield were observed. Total nitrogen application in some cases exceeded 300 lb, that is concerning, given the strict regulatory environment for water quality in California. In these scenarios, fertigation seems a more dynamic tool to adapt nitrogen management during the season.

In conclusion, this work suggested that slow-release fertilizer may remain available for plant uptake during production season and in certain conditions plant vigor and commercial yield may increase. However, pre-plant applications cannot be adjusted during the season and unforeseen rain events can lead to nitrate leaching, while the contribution from non-fertilizer sources of nitrogen can be substantial. In-season fertigation allows to apply nitrogen after the rains and offers flexibility to adjust nitrogen applications with economic benefits, environmental and regulatory relief.

Treatments	Analysis	Dataset	P-value	n	Notes
Pre-plant/ No pre-plant	ANOVA	Total yield	0.156	6	Nested samples (subsamples) summed
Pre-plant/ No pre-plant	ANOVA	Weekly sampling	0.004**	186	Exploratory, treating dates as reps
Pre-plant/ No pre-plant	Repeated measures	Weekly sampling	0.003**	186	Dates nested in rep (i.e. repeatedly measured)

Table 2. Statistical analyses of the yield measured at Ranch 1.

Ranch	Treatment	Residual	Slow release	Fertigation	Total N applied	N In Water	Soil Mineralization	TOTAL N available	Soil type	Ranch yield	Pre-plant fertilizer	Strawberry Variety	Plot yield Jun-Aug
		lb of N/acre	lb of N/acre	lb of N/acre	lb of N/acre	lb of N/acre	lb of N/acre	lb of N/acre		lb of fruit/acre			lb/ac
Ranch 1	Preplant	60	117	0	117	51	60	288	Sandy Loam	86,244*	8-month	San Andreas	38,752
	No Preplant	60	0	158	158	51	60	329		76,000			34,149
Ranch 2	High Preplant	89	18	41	59	173	75	395	Loam	64,000	50:50 8-month and 12-month	Proprietary	
	Low Preplant	89	9	41	50	173	75	386		64,000			
Ranch 3	High Preplant	30	126	20	146	0	45	221	Loamy Sand	88,000	50:50 8-month and 12-month	Monterey	
	Low Preplant	30	63	20	83	0	45	158		70,400			
Ranch 4	High Preplant	47	117	18	117	0	60	242	Sandy Loam	67,500	50:50 8-month and 12-month	Monterey	
	Low Preplant	47	72	18	72	0	60	197		63,000			

Table 1. Nitrogen balance, yield and variety for four ranches in the study. *Estimated value.

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