Soil Nitrate Levels for Surface-Drip Irrigated Cauliflower

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Abstract. *Nitrate contamination in water is an unresolved environmental issue, with high levels having been detected in California's drinking water. Cauliflower is a shallow rooted crop with high demand for Nitrogen (N), thereby providing a challenge to optimizing yield while minimizing nitrate leaching. Nitrate levels were measured within the top four feet of a sandy loam used for surface drip irrigated cauliflower fertilized at three N rates with organic soybean meal (ORG) and conventional UAN. Soil nitrate contents in response to fertilizer showed a higher NO3-N content as compared to Control plots. There was no significant difference between ORG and UAN treated plots, suggesting that nitrate leaching can occur in either case with the use of nitrogen fertilizers. There was an interaction effect of fertilizer type x rate with the greatest soil nitrate content occurring within the 12-24 inches of soil for the plots fertilized with 225 lbs N/acre of UAN32.*

Keywords: Nitrate leaching, surface drip irrigation, soil nitrate, organic fertilizer, urea-ammonium-nitrate, soybean meal.

Introduction

Cauliflower production in California accounts for 86% of the total US production (Geisseler & Horwath, 2015). The harvested area in California for 2010 was 32,900 acres, and the production accounted for 210 million dollars (NASS, 2011). In 2014, the production was 313,6000 tons with an income of 309 million dollars (CDFA, 2015). The Central Coast, South Coast, South Eastern Desert and the San Joaquin Valley (SJV) are the most important producing regions. Around 85% of the total production in the state is located in the coastal regions. Arizona is the second largest producer state, with the regions of the Yuma Valley accounting for only 9% of the US cauliflower production (NASS, 2011).

Cauliflower is practically transplanted and harvested year-round in California, and fields are subjected to high N fertilizer applications to ensure profitable yield. This factor added to the sandy texture of the soils can contribute to ground water nitrate (NO_3) loading. Nitrate- nitrogen (NO_3-N) is a byproduct of the N fertilizers, and excess amounts in water can be harmful to the environment and the human health. The California Department of Public Health has set the safety threshold value for the NO_3-N concentration in drinking water to be under 10 mg/l, and total NO_3 to be at a maximum of 45 mg/l (CDPH, 2014).

Surface drip irrigation has proven to be an efficient tool to manage water and nutrient application. (Thompson et, al. 2000). The adoption of drip irrigation offers a powerful crop management tool and it can also increase water and N fertilizer use efficiency. According to the 4Rs for nutrient stewardship the goal is to minimize groundwater pollution by applying the right source of nutrients, at the right rate, in the right place and at the right time (Bruulsema, 2009). In order to mitigate nitrate leaching from cropland is very important to understand plant-soil-water relationships and to apply the 4Rs rules to irrigation practices in what is commonly refer to best fertilizer management practices (BFMP) (Rigby & Cáceres, 2001).

Objective

Based on the identified priorities for BFMP, the objective of this research was to quantify pre-plant and post-harvest soil NO_3 levels within the top 4 feet of soil for cauliflower grown with an organic soybean meal (ORG) and a conventional urea ammonium nitrate (UAN) fertilizers.

Materials and Methods

The study was located at the California State University, Fresno Farm, on a Hanford fine sandy loam soil for two cauliflower crops with cultivar "incline", planted in Fall 2014 and Fall 2015. The nutrient sources comprised of soybean based organic fertilizer 7-1-2 (ORG) and the conventional urea-ammonium-nitrate (UAN-32) applied at three N fertilizer rates; 75, 150 and 225 lbs/N acre and a Control with no fertilizer addition. Hence, there were seven treatments with the following codes; Control (no fertilizer application), ORG1 (organic fertilizer at 75 lbs/N acre), ORG2 (organic fertilizer at 150 lbs/N acre), ORG3 (organic fertilizer at 225 lbs/N acre), UAN1 (UAN-32 at 75 lbs/N acre), UAN2 (UAN-32 at 150 lbs/N acre) and UAN3 (UAN-32 at 225 lbs/N acre) replicated five times, resulting in a total of 35 plots.

The field was irrigated with a surface drip irrigation system consisting of two lines per bed located in the inner part of the bed with 12 inches of separation. The drip tape was a Eurodrip™ 5/8 "seamless classic, 10 mil, 12" inches emitters spacing, 0.4 gph at 10psi or 0.58 gpm/100ft at 10psi. An Orbit™ 4 station Easy-Dial Electrical Timer was installed to control the irrigation. A manifold with two manual valves, one automatic valve, filter, pressure gauge and flow Meter was also installed as a part of the irrigation system. Irrigation scheduling was based on meeting 100% of crop evapotranspiration (ETc).

Soils were sampled to determine the existing amount of NO_3-N present at the moment of planting using the approach described by Carter (1993). Soil samples were taken pre-planting and post-harvest at four depths; 12, 24, 36 and 48 inches in each of the 35 plots. At each sampling event 140 soil samples were collected for a total of 560 samples over the two years of study.

Soil NO_3-N levels were determined in extracts using the SEAL AQ2 Discrete Analyzer designed for environmental samples including water, soil and plant extracts. The AQ2 uses a 100% optical quality glass cuvette used for precise absorbance measurements, 10mm optimum path length, reagent wedges with on-board cooling, use only 20ul-400ul reagent per test, disposable reaction wells, cadmium coil for reduction of nitrate/nitrite determination, and a flexible software to manage the analyzer and indicate the desired test.

Results

Overall, fertilizer types had a significant effect ($P < 0.001$) on soil NO_3-N concentrations, In 2014, the average NO_3-N concentrations were 1.76 ± 1.35, 11.92 ± 0.78 and 11.71 ± 0.78 respectively for Control, Organic and Conventional treated plots (Table 1). However, the Organic and Conventional plots were not significantly different from each other (Figure 1). For the 2015 study, the mean soil NO_3-N concentrations were: 0.27 ± 0.75, 5.20 ± 0.43 and 5.52 ± 0.43 respectively for Control, Organic and Conventional plots (Table 1), with no significant differences between the Organic and Conventional plots (Figure 2). Generally, the fertilized plots showed significantly higher soil NO_3-N content as compared to Control (Table 1). This difference in the NO_3-N concentrations is due to the fact that plant uptake consumes part of the nitrogen available in the soil, while other portions might be lost either by leaching, denitrification and volatilization (Hartz, 2007).

Table 1: Average (± S.E.) soil NO_3-N content in response to fertilizer type in 2014 and 2015.

	2014	2015
Fertilizer type	NO_3-N mg/l	NO_3-N mg/l
Control	1.76 ± 1.35	0.27 ± 0.75
Organic	11.92 ± 0.78	5.20 ± 0.43
Conventional	11.71 ± 0.78	5.52 ± 0.43

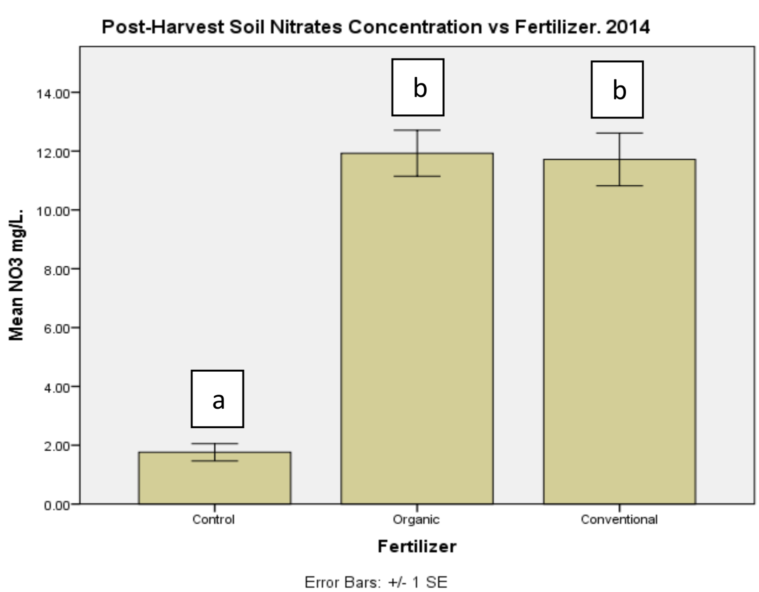

Figure 1: Soil NO_3-N concentrations (mg/l) in response to fertilizer type for 2014.

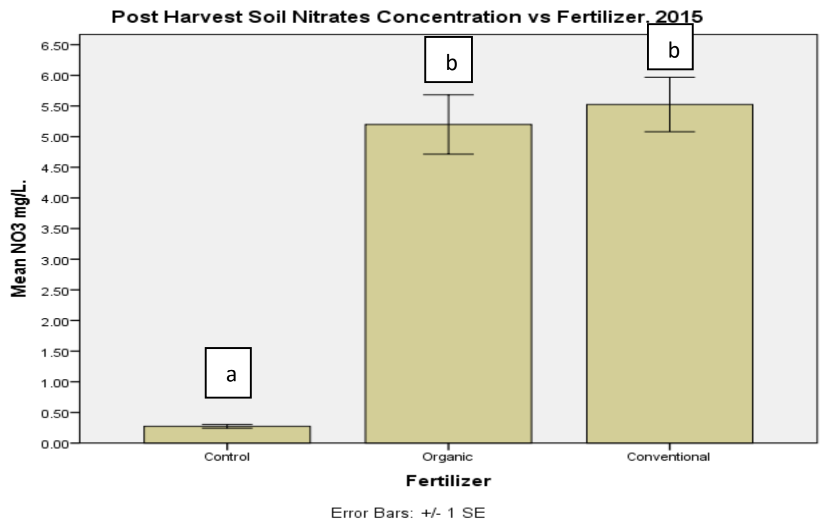

Figure 2: Soil NO_3-N concentrations (mg/l) in response to fertilizer type for 2015.

Soil samples taken at four depths determined that for the higher N rates treatments- ORG2, ORG3, UAN2 and UAN3 there was a trend towards a higher NO_3-N concentration in the 36 and 48 inches as compared to the concentration in the top 12 and 24 inches (Table 2). The elevated concentrations in some plots within the top 12-in of soil were probably the result of mineralization, whereas the higher concentrations within the 36-48-in could be as a result of NO_3-N leaching. Similar results for the NO_3-N concentrations at different depths were reported by Jaynes et al. (2001) on a rotation cropping system in which high NO_3-N concentrations at the top layers of the soil for some years were attributed to nitrogen mineralization. And in years with higher precipitation rates, soil NO_3-N concentrations were higher deeper in the soil horizon, attributed to NO_3-N leaching.

Table 2: Average NO_3-N (±S.E.) concentrations (mg/l) for each treatment at four depths; 12, 24, 36 and 48 inches in 2014.

Treatments	**Control**	**ORG1**	**ORG2**	**ORG3**	**UAN1**	**UAN2**	**UAN3**
Depth (in)							
12	2.7 (±0.74)	6.4 (±3.13)	12.5 (±2.94)	18.7 (±0.92)	8.4 (±1.93)	5.2 (±2.67)	18.5 (±0.92)
24	1.4 (±0.63)	10.6 (±3.74)	11.1 (±2.60)	10.3 (±0.73)	6.7 (±1.78)	8.5 (±2.20)	17.1 (±0.83)
36	1.9 (±0.39)	12.0 (±3.00)	12.3 (±2.49)	15.6 (±2.72)	11.2 (±2.85)	8.5 (±2.54)	17.7 (±0.69)
48	1.0 (±0.28)	7.3 (±2.02)	7.6 (±3.51)	11.2 (±1.48)	7.3 (±1.67)	8.6 (±3.06)	23.2 (±0.79)

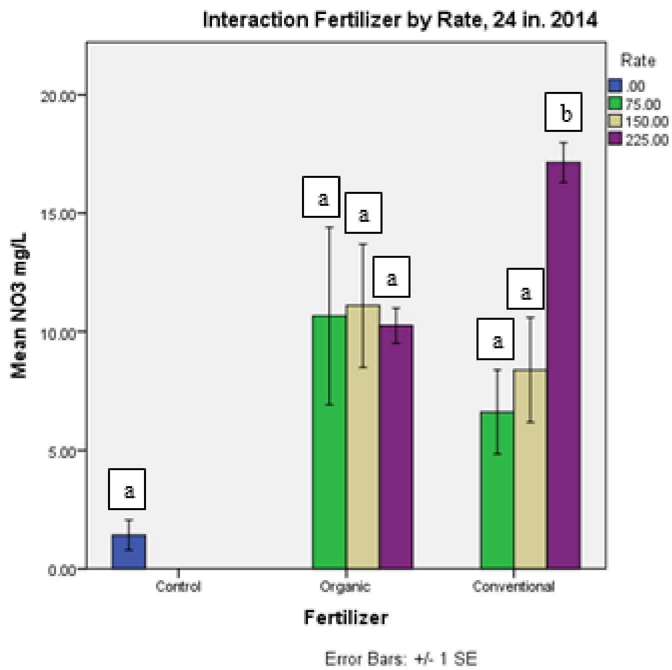

Figure 3: Mean soil NO_3-N concentrations (mg/l) within the 12-24 inches as a function of fertilizer x rate interaction in 2014.

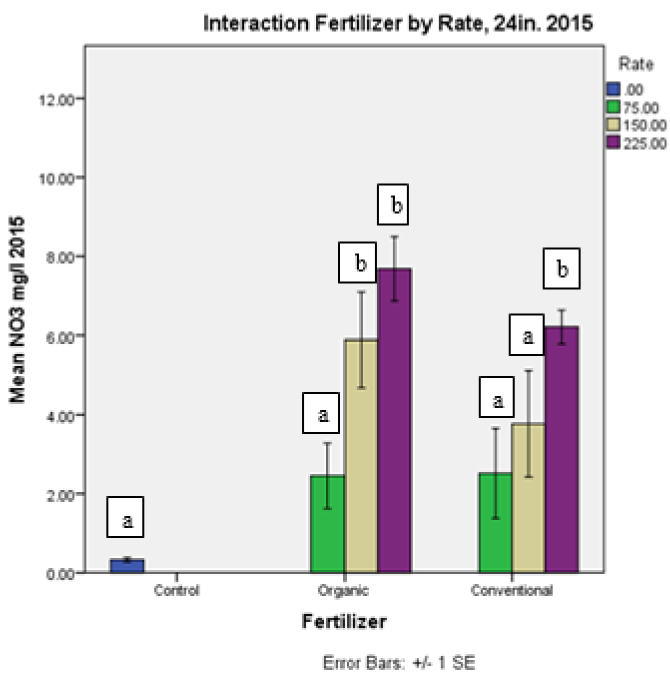

Figure 4: Mean soil NO_3-N concentrations (mg/l) within the 12-24 inches as a function of fertilizer x rate interaction in 2015.

In the top 24-inch of soil for the field study in 2014, there was a significant interaction ($P= 0.043$) between Conventional fertilizer type by the 225 lbs/N acre N fertilization rate (Figure 3). For the 2015 field study there was no significant interaction ($P> 0.05$) among the fertilizer treatments (Figure 4) within the top 24 inch of soil.

Conclusions

Soil nitrate contents in response to fertilizer type showed a higher NO_3-N content as compared to Control plots with no fertilizer addition. However, there was no significant difference between organic (ORG) and conventional (UAN) fertilizers, which suggest that the nitrate leaching might occur in either case with the use of nitrogen fertilizers.

Nitrate content in the soil as a function of depth did not show a significant different among the treatments. Generally, there was an interaction between UAN-32 fertilizer and the highest fertilizer rate of 225 lbs/N acre for the 0-12, 12-24, 24-36 and 36-48 inches of soil.

When combined with the appropriate fertilizer types and application rates, surface drip irrigation is a potentially useful tool to help mitigate the nitrate leaching in a sandy loam soil used to grow shallow rooted cauliflower.

References

Carter, M. R. (Ed.). (1993). Soil sampling and methods of analysis. CRC Press.

CDFA. (2015). California Agricultural Statistics Review. 2014-2015. CDFA. http://www.cdfa.ca.gov/Statistics/ (accessed 15 Feb. 2016)

CDPH. (2014). Nitrate Fact Sheet. http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/nitrate/Fact%20Sheet%20-%20Nitrate_May2014%20update.pdf (accessed 15 March. 2016)

Bruulsema, T. (2009). Recommendation development under 4R nutrient stewardship. In *Proceedings North Central Extension-Industry Soil Fertility Conference* (Vol. 25).

Geisseler, D., & Horwath, W. R. (2015) Cauliflower Production in California. On line: https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Cauliflower_Production_CA.pdf (accessed on 30th March 2016).

Hartz, T. K. (2007). Efficient nitrogen management for cool-season vegetables. University of California, Department of plant Science. UC Davis http://vric. ucdavis.edu/pdf/fertilization_EfficientNitrogenManagementforCoolSeasonveg etable2007. pdf.

Rigby, D., & Cáceres, D. (2001). Organic farming and the sustainability of agricultural systems. Agricultural systems, 68(1), 21-40.

Thompson, T. L., Doerge, T. A., & Godin, R. E. (2000). Nitrogen and Water Interactions in Subsurface Drip-Irrigated Cauliflower II. Agronomic, Economic, and Environmental Outcomes. *Soil Science Society of America Journal*, *64*(1), 412-418.

USDA-NASS. (2011). Cauliflower production in California. USDA-NASS. http://www.nass.usda.gov/StatisticsbyState/California/Publications/Vegetables/201101vegrv.pdf (accessed 05 Feb. 2016)