Optimizing the Use of Groundwater Nitrogen (NO_3^-): Efficacy of the Pump and Fertilize Approach for Almond

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Objective

The goals of this project were to test the pump and fertilize concept (*P&F*) as a realistic alternative to the use of synthetic fertilizers like calcium ammonium nitrate (CAN) and urea ammonium nitrate (UAN).

Methods

Working with growers we established three different N application practices (Advanced Grower Practice – *AGP*, P&F and high frequency low N concentration – *HFLC*) to almond orchards in two hydrogeologically vulnerable area (HVA) in the Central Valley. We have established fully randomized complete blocks designs for the two orchards. (Fig. 1 and 2)

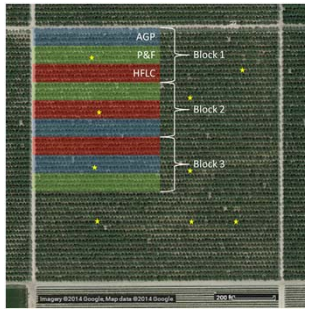

Figure 1. *Basic experimental design. Four rows of trees in each treatment, three replications for each of AGP and HFLC to be contrasted with P&F. Each star represents an intensively monitored location.*

Figure 2. *Microfertiligation dosetrons used in the HFLC subplots.*

Eight sites were selected to represent the different layering in the subsurface horizons for assessment of NO3- leaching below the root zone (Fig. 3).

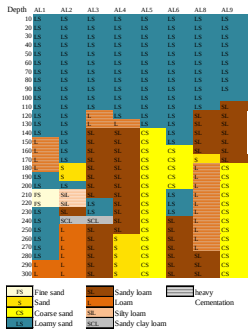

Figure 3. *Different layering under the instrumented sites (AL1-9).*

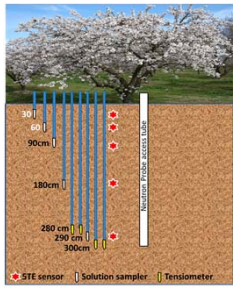

Figure 4. *Schematic representation of the instrumentation setup (not to scale).*

Each one of the eight sites was instrumented with an accesses tube for neutron probe, five solution samplers, four tensiometers, and five 5TE probes (Decagon, Pullman, WA, USA). The installed sensors monitor processes in and below the root zone (Fig. 4 and 5).

Figure 5. *instrumentation setup as it looks in the field*

Results

N loads for the orchard were based on prediction models for almond (Patrick Brown's laboratory; https://www.sustainablealmondgrowing.org). Since mid-March 2014, the almond orchards have been irrigated almost on a weekly basis (total irrigation height 1.1m (43.3 in.). Fertilizer was applied to the orchard on three out of the planed four occasions (215 instead of 280 lb./acre). During each fertigation event, the P&F subplots received ~70% of the planned load (total of 186 lb./acre) and the HFLC subplots received none (Table 1). The HFLC subplots were fertigated during each irrigation event with 5% of the total N-load (280 lb./acre) planned for the season using microfertigators (total of 215.5 lb./acre).

Fertigation event #	Planned		Applied	
	Percentage of total-N (%)	N-amount (lb./acre)	Percentage of total-N (%)	N-amount (lb./acre)
1	20	56	16	45
2	30	84	36	102
3	30	84	24	68
4	20	56		
Total	100	**280**	76	**215**

Table 1. *AGP Nitrogen-fertilizer application for the 2014 growing season. Irrigation water contributed 73.8 lb. N per care*

Treatment	Yield (lb./acre)
AGP	2699 ± 49
P&F	2695 ± 124
HFLC	2869 ± 461

Table 2. *Average yields of kernel per acre (and standard deviation) for the three different N application practices .*

Nitrate was the dominant N-form in the vadose zone, with average concentration of 105 mg/l NO_3^--N (Fig. 6).

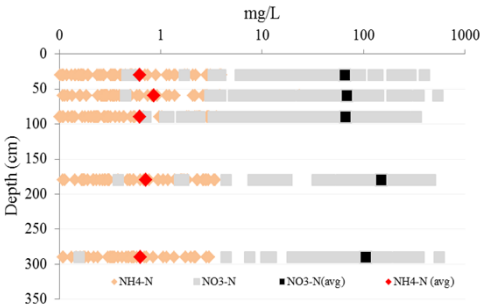

Figure 6. *Nitrate-N and ammonium-N in the vadose zone pore water. The average nitrate-N and ammonium-N concentrations calculated from 230 pore water samples are presented (black square and red diamond). Note the high concentrations at 290cm – suggesting high potential for groundwater contamination (105 mg/L NO_3^--N = 465 mg/L NO_3^-).*

The metric potential and the water content below the root zone indicated minimal water losses in locations were hardpan has developed blow the surface (Fig. 7 and 8)

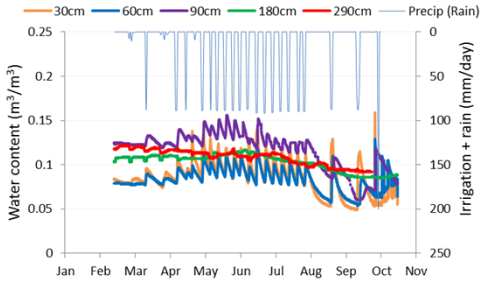

Figure 7. *Temporal changes in the water content of the sediment profile under an instrumented tree, in response to rain and irrigation events.*

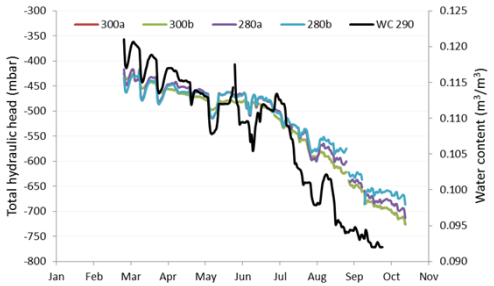

Figure 8. *The relation between the total hydraulic head and the water content below the root zone (280-300 cm below land surface), indicating unit downward gradient conditions.* ***The high matric potentials and the low water content values lead to low hydraulic conductivities (K(θ)<0.001 cm/day) and suggest minimal leaching at places where hard pan developed.***

Conclusions

- **During the first year, three different N application practice treatments were successfully implemented and monitored in almond orchards.**
- **The P&F did not decrease the yield, while the HFLC slightly increased the yield, albeit not at statistically significant levels.**
- **High nitrate concentrations below the root zone (>290cm) suggest high potential for groundwater contamination.**
- **High matric potentials and low water contents below the root zone suggest minimal leaching and groundwater recharge on place where hard pan developed.**

Acknowledgements

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